
ERGONOMÍA OCUPACIONAL
INVESTIGACIONES Y APLICACIONES

VOL. 12

ERGONOMÍA OCUPACIONAL

INVESTIGACIONES Y SOLUCIONES

VOL. 12

EDITADO POR:

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2019 Sociedad de Ergonomistas de México A.C. (SEMAC)
ISBN: 978-0-578-48915-5

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COGNITIVE ANALYSIS IN THE TASK OF PASSENGERS BOARDING IN PUBLIC TRANSPORT IN CIUDAD JUAREZ, MEXICO

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Resumen: En la conducción de autobuses de transporte público la seguridad es un elemento muy importante, en el cual el factor humano es primordial en la prevención de accidentes, el objetivo de este artículo fue analizar la tarea de los conductores al subir pasajeros a los autobuses e identificar factores de riesgo, se aplicó el método de carga mental NASA-TLX a cinco conductores de una línea de autobuses de transporte público en Ciudad Juárez, México, se les hizo una entrevista y se realizó una observación de la tarea analizada, con el fin de hacer un análisis jerárquico de tareas y una evaluación con el método de error humano SHERPA. Como conclusión del estudio se obtuvo que la tarea examinada tiene una importante carga de estrés en los conductores, en el análisis jerárquico de tareas y el método de error humano SHERPA se detectaron cuatro errores que pueden poner en riesgo la seguridad de los pasajeros o provocar un accidente vial, y finalmente con la evaluación del método de carga de trabajo NASA-TLX se obtuvo que todos los conductores tenían un nivel de carga mental alto al realizar la tarea de subir pasajeros al autobús.

Palabras clave: Análisis jerárquico de tareas, carga mental, conducción, transporte público urbano.

Relevancia para la ergonomía: Es importante un análisis de la carga de trabajo de los conductores de transporte público por la responsabilidad que este trabajo implica, y para conocer los factores de riesgo que se presentan durante el ascenso de los pasajeros a los autobuses.

Abstract: Safety is very important when driving public transport buses, the human factor is essential for the prevention of accidents. The objective of this article was to analyze the task of bus drivers when boarding passengers to identify risk factors, the NASA-TLX mental load method was applied to five drivers of a bus line in Ciudad Juarez, Mexico, an interview was conducted and an observation of the analyzed task, in order to make an Hierarchical task analysis and an evaluation with the SHERPA human error method. As conclusion of the study it was obtained that the

analyzed task has a significant load of stress on drivers, with the hierarchical task analysis and the SHERPA human error method, four errors were detected that could put at risk the passengers safety or cause a road accident, and finally with the evaluation of the workload method NASA-TLX it was obtained that all drivers had a high level of mental load when boarding passengers to the bus.

Keywords: Hierarchical task analysis, mental load, driving, urban public transport.

Relevance to Ergonomics: An analysis of the workload of public transport drivers is important for the responsibility that this work implies, and to know the risk factors that are present during passengers boarding to buses.

1. INTRODUCTION

Urban public transport driving requires an important responsibility since it implies the safety of the passengers and other drivers, according to the Highway Traffic Safety Administration (NHTSA), the human factor would be involved between 71% to 93% of traffic accidents; route factors, between 12% and 34%; and those of the vehicle, between 4.5% and 13% (Aguirre, 2017). The number of traffic accidents is on the rise, according to Aguilar (2010) if the observed trends persist, by 2020 the number of people dead or disabled each day on the roads and streets of the world will have grown more than 60%.

The mental demand that driving cars requires, according to Chaparro and Guerrero (2001) leads to experiencing fatigue, that can result in drowsiness, sleepiness, irritability, difficulty in concentration, back pain, leg pain and eye pain. As a consequence, in the long term, chronic fatigue can occur, the result of an inappropriate rest-work relationship and an inadequate recovery derived from work demands that often involve long working hours.

The issue of mobility has had an increasing importance in recent years, in this sense, public transport is a topic of interest in today's society for different reasons (Anguita, Duarte & Flores, 2014). Public transport is a fundamental tool to solve urban transport problems and achieve an efficient and equitable city, since it is more efficient than private motorized in terms of passengers transported per unit of space, energy consumption and environmental impacts (Pardo, 2009).

Driving public transport vehicles is a very stressful job, drivers have intense work days, facing hazards due to time, distance, road conditions, passengers accommodation and mechanical attention of the unit, all this, lacking occupational safety and professional qualification (Salazar & Pereda, 2010), as mention Chaparro and Guerrero (2001) urban public transport drivers work is characterized by a high frequency and a simultaneous execution of tasks, and exposed to noise and vibration; high density of traffic and continuous stops. On average, more than 200 tasks per hour are carried out during driving, its execution requires particular attention in relation to those performed with the parked vehicle.

It is difficult to consider any occupation or profession that does not involve stress, given the speed and demands in which people are immersed (Lima & Juárez,

2008), but "Drivers are subject to a high level of work stress, rather than workers from other occupations. Urban public transport driving is one of the most stressful trades. Stress and vehicle driving are intimately linked: stress modulates to a large extent the driving style of people and can be the cause of a considerable number of accidents and can also cause negative effects on the driver as generation of higher levels of hostility and competitive behaviors; greater tendency to impatience, risky decision-making and reckless driving; decrease in concentration; and the negative effect of the uncontrolled use of drugs, alcohol or other substances that can be used to reduce stress" (Aguirre, 2017).

2. OBJECTIVES

In Ciudad Juarez the issue of public transport has been of interest since decades ago, mainly due to the deficiencies that this presents, "it is provided with old buses, these are from companies of the private initiative; usually the buses are in very bad physical and mechanical conditions" (Bayardo, Medina, & Aranda, 2013), in addition to this problem, in infrastructure, as in the case of the city downtown, the urban layout has narrow streets, that at certain times of the day, show a traffic chaos, the problem is aggravated by the continuous circulation of public transport, with a tendency to make stops in improper places (Gallegos & Lopez, 2004), this study focuses on the drivers, on analyzing the tasks they perform when boarding passengers to the units and identifying the risk factors that arise, according to Aguirre (2017) "it was not until the middle of the 20th century that research began on occupational health of urban transport drivers, in this sense the works published by Morris and colleagues (1953, cited in Aguirre, 2017) established the potential harmful nature of driving. Among the variables that most affect the driving work, we can name the environment and the health status of the drivers".

It becomes important to evaluate the mental load on this group of workers, such as the time pressure of the task (time available, time needed), the amount of processing resources that the task demands and aspects of an emotional nature such as fatigue and frustration (Olivares, Jélvez, Mena & Lavarello, 2013).

3. METHODOLOGY

Stage 1: To carry out this study, the issue of public transport in the city was chosen, then a review of literature was made, with many studies on the subject found, an exploration of this service in the city was made, it was decided to do the study with a specific task performed by bus drivers: board passengers to the bus, and a single line of buses were selected, so the drivers were under similar working conditions. It was selected the 5A bus line in the city downtown, which is an important point of buses arrival.

The evaluation of the mental load method NASA-TLX was applied to five drivers, previously the six dimensions that the method addresses were explained to them: mental demands, physical demands, temporal demands, performance, effort

and level of frustration, and based on these, they had to mark in a table the aspect of the presented pair that contributed more load in the task of boarding passengers to the bus.

M – F	F – T	T – E
M – T	F – R	T – Fr
M – R	F – E	R – E
M – E	F – Fr	R – Fr
M – Fr	T – R	E – Fr

Figure 1. Selection of aspects that contribute most to mental load, NASA-TLX

In the evaluation, a scale with 20 spaces is also managed, in which the evaluated person fills the part that considers as representative of the load in each of the six dimensions.

Mental demand. How mentally demanding is the task?

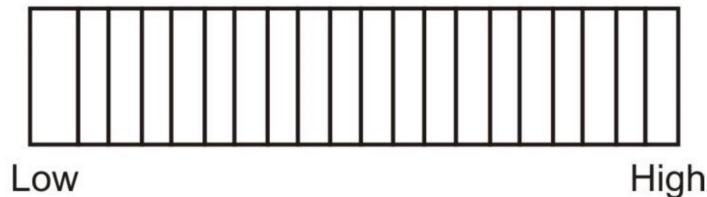


Figure 2. Scale with mental demand dimension, NASA-TLX

After the evaluation, a small interview was made to each one of them to obtain more data, among the information provided, they mentioned that boarding passengers to the bus was a stressful task since they have to comply with established times and this task can delay them, most of them mention that at the end of the day the stress is greater than at the beginning of the day, another fact they mentioned was that sometimes it is difficult to deal with the passengers because they were in a bad mood, also, traffic was an important stress factor.

Stage 2: On the selected bus line, a unit was boarded to take a tour and observe the tasks performed by the driver when boarding passengers, in order to subsequently perform a hierarchical task analysis and an evaluation with the SHERPA human error method.

Stage 3: During the observation, notes were taken, the task was analyzed from the moment of driving, when a person requested to board the bus by a hand signal, boarding the bus, the driver receiving the money and giving change, and the bus returning to traffic, with this information a hierarchical task analysis was done.

Stage 4: The evaluation of the mental work load carried out with the NASA-TLX method was done boarding the transport units that arrived after a route, when drivers had a free time before leaving again; they were explained about the evaluation purpose.

Stage 5: To carry out the SHERPA human error method, the hierarchical task analysis mentioned above was used, with which the task was categorized, there were errors, consequences and repair strategies identified.

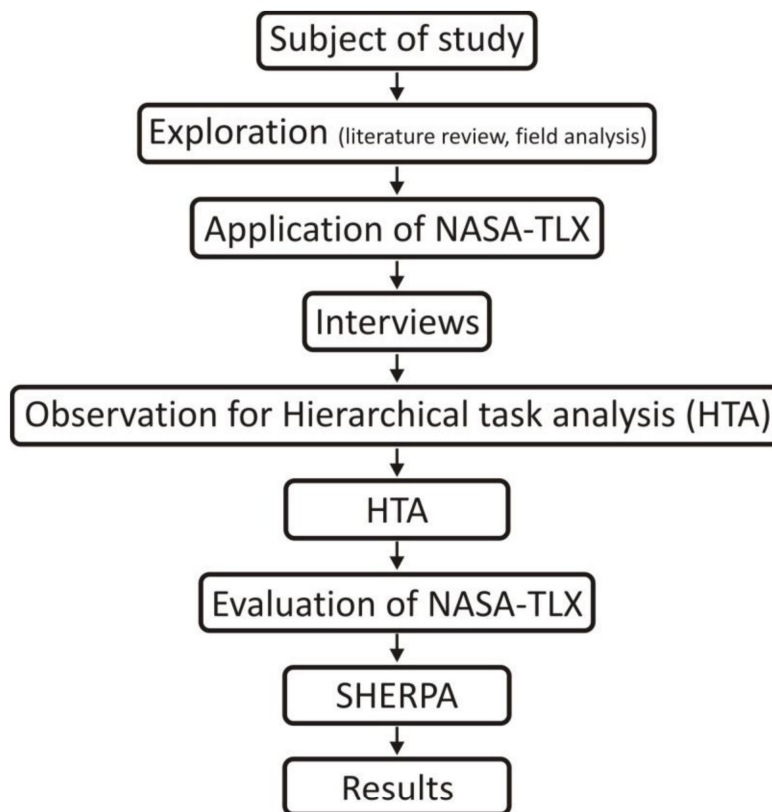


Figure 3. Methodology

4. RESULTS

Stage 1 results: From the information provided by public transport drivers, the result was that the task of stopping to board passengers had a significant stress load, mainly due to the time they have to complete the route, the traffic and passengers' mood.

Stage 2 results: In the bus that was boarded to observe the tasks performed by the driver, some risk situations were observed that will be detailed below.

Stage 3 results: In the hierarchical task analysis, based on the observations, four errors were identified that were detailed in the SHERPA human error method.

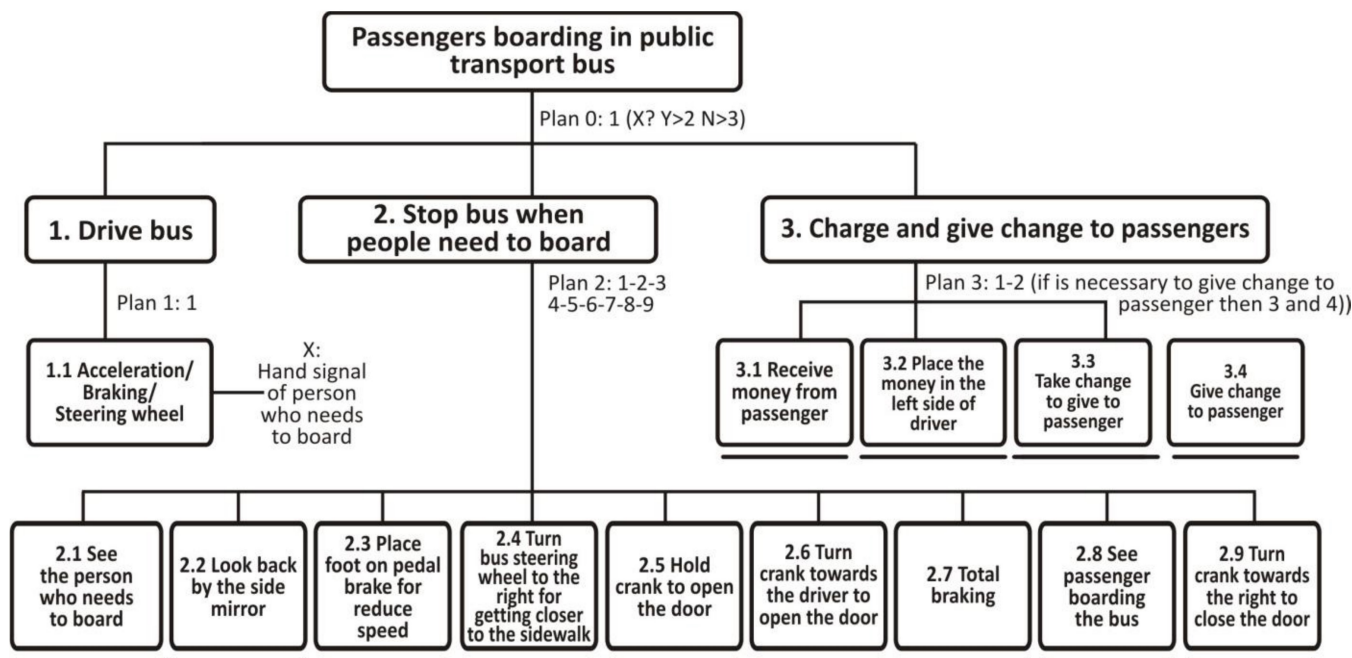


Figure 4. Hierarchical task analysis in passengers boarding a public transport bus in Ciudad Juarez, Mexico

Stage 4 results: The evaluation made with the NASA-TLX method resulted in a high mental load level in the five drivers with the task of boarding passengers to the bus.

Table 1. Drivers' weighted scores obtained with the NASA-TLX method

Variable	Weighted score Driver 1	Weighted score Driver 2	Weighted score Driver 3	Weighted score Driver 4	Weighted score Driver 5
Mental Demand	0	0	50	0	55
Physical Demand	200	35	0	400	240
Temporal Demand	500	340	225	180	320
Performance	200	100	400	300	500
Effort	200	500	110	55	150
Frustration	400	150	500	500	0
TOTAL	1500	1125	1285	1435	1265

According to the score table of this method, a global evaluation of 1000 points is considered within the high load level, a medium load level would be above 500 points and below 1000 points, while a low level of mental load would be of 500 points or less.

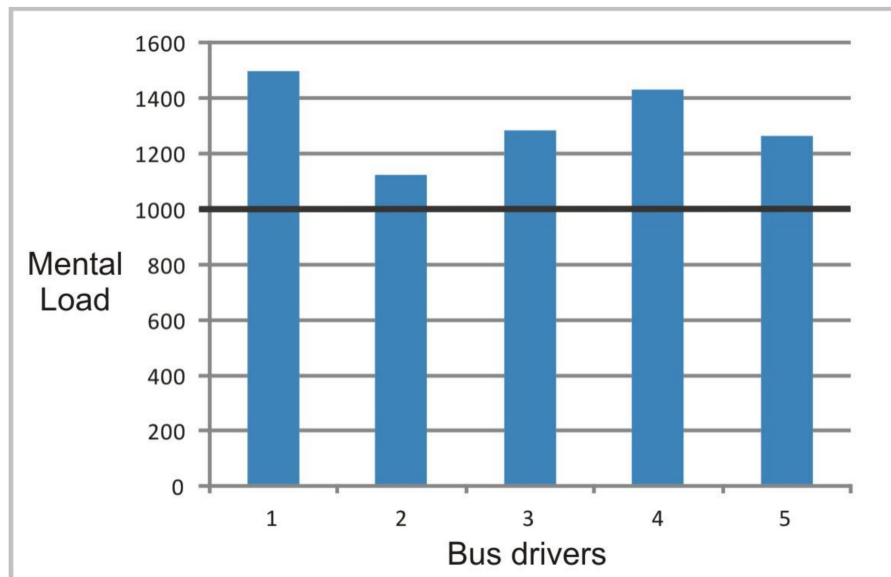


Figure 5. Results of drivers' mental load with the NASA-TLX method

Stage 5 results: With the SHERPA human error method, four errors were detected during the completion of the task, to which repair strategies were proposed.

The detected errors were classified within the action errors: correct activity in the wrong object, the activity is too short and there are a lot of activities.

The first error, stop to board passengers anywhere, and not only in the marked places took the bus to stop unnecessarily on several occasions as there were people who were waiting for other buses.

Another error detected was approach the sidewalk to board the passengers without due caution, sometimes it was omitted to see through the rearview mirror or it was done very quickly before performing the necessary actions, which could cause an accident.

Another mistake was open the door while he was driving to bring the bus to the sidewalk to board the passengers.

Finally, the time allocated for the passenger to board was very short, the person still did not finish boarding and the bus was already in motion, what forces the passenger to maintain balance so as not to fall.

Table 2. Errors detected with SHERPA method.

Task step	Error mode	Error description	Consequence	Recuperation	P	C	Repair strategy
2.1 See The person who needs to board the bus	A6	Fail to distinguish if the person wants to board or not, some people do not make a sign with their hands	Sometimes people do not board, they are waiting for another bus	Immediate	L	L	Stopping to board passengers only in the signed places
2.2 Look back by the side mirror	A1	Failure in observation through the mirror,	A probable accident with the vehicles, motorcyclists or cyclists coming	Immediate	M	M	Training in road accident prevention

		is very fast or it is omitted	behind the bus				
2.6 Turning crank towards the driver to open the door	A4	Failure to carry out this task along with driving the bus	There is no total concentration driving the bus	Immediate	L	L	Instruction to drivers of a procedure for passengers boarding
2.8 See passenger boarding the bus	A1	Failure in the time allocated for the passenger to board the bus, it can be very short	Passenger may fall or lose balance, because many times bus is set in motion during passenger boarding	Immediate	M	M	Instruction to drivers of a procedure for passengers boarding

5. CONCLUSIONS

The deficiencies that public transport presents in Ciudad Juarez, Mexico, show the lack of regulations that exist in this sector, the work conditions of public transport drivers originate in these high levels of stress.

An improvement in the public transport system would be beneficial in different aspects, such as social, environmental, economical, political and urban; in addition, this would benefit for the city to decrease the use of private vehicles.

In this study was only analyzed the task of boarding passengers to the bus, with the help of hierarchical task analysis and SHERPA human error method, four errors were detected that involved the safety of the passengers and another drivers, and could cause an accident, it is very possible that important errors would be found if other tasks performed by bus drivers were analyzed. It is concluded that boarding passengers is an important cause of stress in bus drivers, a better organization of this task, with an improvement in the times to board the bus, would help to reduce the mental load and reduce risk factors.

6. REFERENCES

- Aguilar-Zinser, J. V. (2010). La situación actual de los accidentes en el mundo I ntroducción, 384–388.
- Aguirre, L. (2017). Condiciones psicosociales y de salud general en una muestra de conductores de buses de transporte público de pasajeros. *Revista de Salud Pública, (Ed. Especial)*, 28–36.
- Anguita Rodríguez, F., Duarte Monedero, B., & Flores Ureba, S. (2014). Situación actual del transporte público urbano: La visión de las empresas operadoras. *Investigaciones Europeas de Direccion Y Economía de La Empresa, 20(1)*, 16–22. <https://doi.org/10.1016/j.iedee.2013.10.003>
- Bayardo, J., Medina, M., & Aranda, N. (2013). El adulto mayor como usuario del transporte Público de ciudad Juárez, Chihuahua México. *El Adulto Mayor Como Usuario Del Transporte Publico de Ciudad Juárez, Chihuahua México*.
- Carla C., A. L. J. A. (2008). Estudio exploratorio sobre estresores laborales en conductores de transporte público colectivo en el estado de Morelos, México. *Revista Ciencia Y Trabajo, 30*, 126–131.
- Chaparro, P., & Guerrero, J. (2001). Condiciones de Trabajo y Salud en Conductores de una Empresa de Transporte Público Urbano en Bogotá D.C. *Rev. Salud Pública., 3(2)*, 171–187. Retrieved from <http://www.revistas.unal.edu.co/index.php/revsaludpublica/article/view/18674>
- Concepción, S., Sandra, I., & Santos, P. D. L. (2010). SÍNDROME DE BURNOUT Y PATRONES DE COMPORTAMIENTO ANTE TRÁFICO EN CONDUCTORES, 141–169.
- Oswaldo Gallegos, A. L. (2004). Turismo y estructura territorial en Ciudad Juárez, México. *Investigaciones Geográficas, Boletín Del Instituto de Geografía, UNAM, 53(53)*, 141–162. Retrieved from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-46112004000100009&lng=es&nrm=iso&tlng=es
- Pardo, 2009. (2009). Los cambios en los sistemas integrados de transporte masivo en las principales ciudades de América Latina, 1–28. Retrieved from <http://repositorio.cepal.org/handle/11362/3641>
- Víctor E. Olivares Faúndez, Carolina Jélvez Wilke, Luis Mena Miranda, J. L. S. (2013). Estudios sobre Burnout y Carga Mental en Conductores del Transporte Público de Chile (Transantiago). *Cienc Trab., vol.15(no.48)*.