ANNALS OF THE UNIVERSITY OF ORADEA
Fascicle of Management and Technological Engineering
ISSUE #3, December 2016, http://www.imtuoradea.ro/auo.fmte/

COMFORT ASSESSMENT IN A VEHICLE

Doru CONSTANTIN[1], Mihai NAGI[2], Ana-Andreea MIHARTESCU[3], Crisanta-Alina MAZILESCU[4]
[1]Politehnica University Timisoara, doru.constantin@upt.ro
[2] Politehnica University Timisoara, mihai.nagi@upt.ro
[3] Politehnica University Timisoara, andreea.mihartescu@upt.ro
[4] Politehnica University Timisoara, alina.mazilescu@upt.ro

Abstract— The aim of this paper is to identify the perception of a group of students of a technical University on comfort in cars and to determine if the lack of comfort is estimated to be producing discomfort. 48 subjects, young drivers or passengers participated in the study and were investigated in connection with the main elements of comfort experienced in the car. Valuation of comfort was based on descriptions of study participants, descriptions in which they were asked to specify what they perceive as a car's elements that produce comfort. On the one hand, the results show us a representation of what does comfort for young drivers mean, and on the contrary, the results indicate that there is variability in terms of items that produce comfort, and whose absence can generate or not, discomfort.

Keywords— vehicle, comfort, discomfort, assessment

I. INTRODUCTION

COMFORT is a complex concept, difficult to define, used in many disciplines sometimes with very different meanings. Initially, by comfort one could understand 'encouragement, support, help "or rather" what gives "courage", what makes you strong "(derived from the Latin *confortare*), and later, in the nineteenth century, to take the meaning of "material wealth" (from the English comfort).

Comfort and discomfort were often studied in terms of ergonomics. Based on the rating scales GCR - General Comfort Rating) and BPD - Body Part Discomfort Scale, Berthelot and Bastien established the existence of 11 kinds of comfort: dimensional comfort, user comfort, contact, posture, interaction, eco-design, comfort the also the comfort given by the chosen materials, sensorial comfort, dynamic and hygrothermal and physical environment comfort, by Berthelot and Bastien [1].

Dimensions of comfort can have defining aspects of both physical quantities of ambiance and behavioral or psychological issues.

At a physical or physiological level there have been identified and defined visual, thermal, acoustic or respiratory comfort, and there were set values or ranges of real values characteristic of each of them in different contexts (e.g., the value of thermal comfort are different in different seasons). For each of our senses, there have been defined comfort areas / ranges. Comfort range is different from person to person, but differ depending on the context or duration of exposure to a particular environment (public, private, labor, etc.);

At the behavioral level comfort is given by a person's ability to act and control the environment so as to limit the unpleasant aspects of behavioral adjustments (adaptive comfort). In other words, the adaptation behavior refers to any conscious or unconscious behavior changes as a result of a situation experienced. For example, consumption of hot or cold drinks, opening or closing a window, initiation or cessation of heating, etc. From the same perspective, we are talking about comfort and functional within the scope of study of ergonomics and is more oriented towards streamlining tasks at work or household tasks and less by personal satisfaction.

Psychologically comfort depends on generating emotions or pleasures, but also on the possibility of taking decisions or on the awareness of the ability to control the environment and to anticipate the consequences of their actions on the environment. For example, holding the control consciousness of a particular source of discomfort involves certain psychological mechanisms that help us to be more tolerant of the discomfort compared to the situation where we do not realize we have control over the source of discomfort.

Comfort in vehicle transport occupies a prominent place in current research focusing on the comfort of the train, airplane, buses and autos.

A. Comfort in train

The study of the behavior of passengers on the train is based mainly on the analysis of video recordings of the passengers during train journeys where there can be in identified a succession of positions which seek to stabilize movements and a decrease the muscle activity. We can quote in this regard the study of Branton [2] and Branton and Grayson [3] analysis that took into 45,000 passengers.

Favre and Flores proposed an indicator of overall comfort based on three factors of comfort, Flores and Favre [4]: Physical factors that include both physical space and other factors rapidly evolving; Social factors incorporating customer expectations concerning the

organization of the transport mode; Individual factors that include path-factor motivation, associated with the present travel experience.

Another attempt to develop a higher overall comfort index was made by INRETS. They proposed an index based on the interaction of six partial comfort indices namely seats, train ride-quality, natural ambiance elements (heating, ventilation, and lighting), noise, toilets, arrangements that facilitate the movement of passengers in the train.

B. Comfort in plane

Research related to comfort in the aircraft is heading specifically to the study of comfort in the cabin, comfort determined not only by the width and the distance between the seats but also temperature and currents of air conditioning and sound environment where there are passengers.

Berthelot and Bastien focus on the following criteria in assessing comfort in flight Berthelot, Bastien [1]:

1) static criterion: space and time (immobility, inactivity);
2) dynamic criterion (acceleration, vibration, etc.);
3) physical ambient (temperature, humidity, light, noise, oxygen);
4) aspects related to design (shape, material, color, etc.).

Hadibroto believes that the perception of comfort is different depending on the gender of passengers, Hadibroto [5]. Passengers women consider important in short flights dynamic factors, seat quality, noise, vibration, temperature and air pressure changes in the cabin. Hierarchy comfort to men is represented by thermal comfort, the seat, acoustic comfort and dynamic space availability factors.

Evaluation of comfort can change the order in hierarchies presented according to the needs and activities that take effect during the flight: reading, resting, sleeping, eating, working at the computer, etc.

C. Comfort in cars

Comfort in vehicles was and still is the concern of all the manufacturers regardless of time and place thereof. Aspects of comfort should be related to the traffic safety in such a manner that both issues are satisfied. The same time, reducing energy consumption measure should be considered. For example, an increase in the size of car windows make summer an excellent solar captor by the greenhouse effect which is formed inside the car but enhances the risk of accidents. Watertight common passenger areas reduce heat loss and noise from the machine and its external environment, but forbiddeth natural air renewal of vehicle. Good yields of the new engines reduce energy lost, otherwise valuable energy in winter to heat the passenger compartment.

Evaluation the comfort in cars require both knowledge of physics (for transfers' heat between the human body and the environment) and a minimum knowledge of human physiology. A scientific approach to thermal comfort requires both studies of the thermal equilibrium of the human body and study sensitive parameters of thermal comfort: temperature (ambient walls, body surface), atmospheric moisture, temperature differences' in space and time) air movements.

The temperature in the cabin is a major factor in the production of road accidents. Daanen, E van de Vliert, Huang [6]. Zlatoper investigated the influence of 10 factors in traffic accidents in the United States and noted that the temperature was ranked the third position, Zlatoper [7]. A better system climate control in an automobile improves the thermal leading to an increase in prudence driver, and traffic safety improves performance in different traffic conditions. Research shows that the air conditioning is one of the most valuable automotive comfort equipment. Improving performance cooling system of a car requires a careful analysis of system components. A system should maintain optimal thermal comfort during variations in thermal loads while minimizing power consumption

Sizing air conditioning in transport vehicles is done by thermal needs of passengers / travelers, in order to maintain the desired habitat vehicle passenger comfort temperature. In the warm period, there should be taken into account the compensation of the difference between the air temperature inside the vehicle and the temperature of the new air introduced in the vehicle, the heat loss due to walls and windows, the heat losses from distribution pipes. In the cold, one must compensate for the difference in temperature and humidity of the air inside the vehicle and the air temperature and humidity newly incorporated vehicle caloric intake due to walls, caloric intake due to distribution lines, caloric intake due to solar heating through walls and windows, contributions internal in calories and moisture due to passengers, lighting and ventilation, Cléon, Pujol, Balacey, Leblon, Robin, Rougier [8].

II. METHOD

A. Participants

The investigation of perceptions regarding comfort in vehicles was conducted on a group of 48 students of the Polytechnic University of Timisoara, belonging to different faculties, namely: Faculty of Automation- 45,70%, Faculty of Chemistry- 7,3%; Faculty of Electrotechnics- 6,70%, Faculty of Management in Production- 7% and Faculty of Communication Sciences- 33,30%. The average age is 19.6 years for our participants. In what regard the sex, 25% of the participants are male, and 75% are female. Regarding the quality of the driver or passenger is the following situation: 43,8 % passengers and 56,2% drivers.

B. Procedure

Comfort evaluation was based on the analysis of the study participants' descriptions. They were asked to perform in own writings a brief overview of the elements they considered are generating comfort in a car, and also

mentioning their position in the vehicle of driver or passenger.

The results from this study were analyzed and compared with the results obtained in a previous research aiming discomfort in vehicles.

C. Method of analysis of responses

Responses were processed through a content analysis that allowed dividing the elements generating comfort into homogeneous and differentiating categories. Categories were made taking into account the item / object generating comfort and not its functionality. And so, there were introduced in the same category different functionalities of the same element, but took into account the frequency of occurrence of the element that is to score each of its functionalities.

III. RESULTS

A. Descriptive analyses of comfort

The analysis of 48 descriptions about comfort generating elements in a car led to the establishment of 36 elements for assessment.

Elections percentage for each category is shown in table I.

TABLE I
ELEMENTS GENERATING COMFORT

Elements	Percen-tage	Elements	Percen-tage
accessorie_infoRoad	18,75	radio_music audio	70,83
air_smell	22,92	reliable	10,42
airbag	6,25	safety	16,67
brake	4,17	seat_chair_bench	77,08
car_color	8,33	silent_car	25,00
central_locking	25,00	size_car	18,75
cleanliness_orde	10,42	suspension	16,67
climate_heat	68,75	space_bar	33,33
consumption	18,75	steering_wheel	10,42
design_car	20,83	trunk	22,92
diesel_fuel_gasol	10,42	tapestry	4,17
doors	8,33	technical_ maintenance	12,50
gearbox	10,42	traction	6,25
Info_onboard computer	29,17	visibility	14,58
interior_ car_color	4,17	window	37,50
lights_headlight	10,42	windscreen	16,67
mirrors	12,50	wiper	16,67
motor	20,83		
Power_Steering	35,42		

Compared to the overall factors included in the study, the percentage of elements generating comfort in a car is presented as follows (table II):

TABLE II
HIERARCHY OF MAIN FACTORS GENERATING COMFORT

Elements	Percentage
seat_chair_bench	9,95 %
radio_music_audio	9,14 %
climate_heat	8,87 %
window	4,84 %
Power_Steering	4,57 %
space_bar	4,30 %
info_state_car_ onboard computer	3,76 %
central_locking	3,23 %
silent_car	3,23 %
…	
Total	100 %

From the descriptions of the students investigated, chairs, music and climate are considered to be elements whose presence is generating the most comfort. At the opposite pole, items are generating the least discomfort, like the color of the vehicle, upholstery, and the brake system.

Regarding the differences between women and men in appreciation comfort, we have identified these significant differences at $p < 0.05$ (table III). Women give greater importance in generating comfort to the following elements: air quality, climate, and space inside the car. Also, the size of the vehicle generates comfort for women to the extent that the car is small and can be easily parked.

TABLE III
SIGNIFICANT DIFFERENCES BETWEEN MEN AND WOMEN REGARDING THE COMFORT

Difference F - M	Square Phi	Level of significance
air_smell	$\chi = 10$	$p < 0,05$
climate_heat	$\chi = 6,82$	$p < 0,05$
size_car	$\chi = 9$	$p < 0,05$
radio_music_audio	$\chi = 11,76$	$p < 0,05$
safety	$\chi = 8$	$p < 0,05$
chair_bench	$\chi = 11,92$	$p < 0,05$
space_bar	$\chi = 6,25$	$p < 0,05$
steering_wheel	$\chi = 5$	$p < 0,05$

As regards the differences between drivers and passengers in comfort appreciation, there was identified only one significant difference in terms of engine power; drivers are those who include powerful engines among the comfort generating factors.

B. Comfort analysis compared to the absence of discomfort

With reference to the results obtained in the study of

factors generating discomfort, D. Constantin, Nagi and Mazilescu [9] the seats, the space inside the car and climate are the elements with the highest potential to produce comfort but also to produce discomfort.

In a situation somewhat similar to the examples presented above there is also an appreciation for the radio and the music in the car; these elements being ranked 7th in generating discomfort (4.95%) and 2nd in the category of items generating comfort (9.14%).

The air in the vehicle has an increased potential to generate discomfort (8.65%) but is seen as having a less significant role in generating comfort (2.96%). Perceived noise in the vehicle cabin is generating discomfort (6.80%), but the silent running vehicle is not necessarily seen as generating comfort (3.23%).

IV. CONCLUSIONS

Car comfort is a major factor for vehicle manufacturers that are trying to make products increasingly more attractive and popular.

For this reason, customer perceptions on comfort in the car become an important source of information for vehicle manufacturers.

Comfort and discomfort are two complementary concepts, closely related to one another; comfort is sometimes defined as the absence of discomfort. The seats, the space inside the car and climate are elements generating comfort if they satisfy the occupants or may be elements generating discomfort otherwise. The debate about the bipolarity of comfort - discomfort dimension, Zhang, Helander and Drury [10] still continues today. Some of the results agree with bipolarity dimension of comfort-discomfort, and the other part show that the presence of elements may bring satisfaction relaxation pleasure without the situation in which the absence of these elements is generating discomfort (eg noise perceived in the cabin of the vehicle).

ACKNOWLEDGMENT

This work was partially supported by the grant POSDRU/159/1.5/S/134378, inside POSDRU Romania 2007-2013 co-financed by the European Social Fund Investing in People.

REFERENCES

[1] S. Berthelot, J. M. C. Bastien "The contribution of ergonomics to the design of product: an application to airplane passenger seats. Paper presented at the ERGODESIGNFORUM 8-10 Juin 2009.

[2] P. Branton, "Behaviour, body mechanics and discomfort", *Ergonomics*, vol. 12, n^0 2, pp.316-327, 1969.

[3] P. Branton and G. Grayson, "An evaluation of train set by observation of sitting behavior". *Ergonomics*, vol. 10, n^{0}1, 35-51, 1967.

[4] J. L. Flores, B. Favre, The comfort of rail vehicle doors: problematic and method of approach, (Le confort du passager de vehicule ferroviaire : problematique et methode d'approche), *Revue generale des chemins de fer*, pp.189–196, 1983.

[5] A. Hadibroto, Proposed methodology of industrial design for improved passenger seating comfort in air transport (Proposition d'une méthodologie de design industriel pour l'amélioration du confort des sièges des passagers dans le transport aérien), Thèse nouveau doctorat UTC, 1992.

[6] H. A. M. Daanen, E van de Vliert, X. Huang. "Driving performance in cold, warm, and thermoneutral environments", *Applied Ergonomics* 34 (6), 597-602, 2003.

[7] T. Zlatoper, "Determinants of Motor Vehicle Deaths in the United-States", *Accident Analysis and Prevention*, 23 (5): 431-436, 1991.

[8] L. M. Cléon, C. Pujol, J. F. Balacey, G. Leblon, P. Robin, P. Rougier, What's new on the air conditioning on board (Quoi de neuf sur la climatisation à bord), *Revue Générale des Chemins de Fer*, (3) 15-26, 1999.

[9] D. Constantin, M. Nagi and C.A. Mazilescu, "Elements of discomfort in vehicles", *Procedia Social and Behavioral Sciences*, 143 pp. 112.-1125, 2014.

[10] L. Zhang, M. G Helander and C. G. Drury, "Identifiyng factors of comfort and discomfort in sitting". *Human Factors*, 38, pp. 377 – 389, 1996.