Influence of Information Flows on the Results of a Driver's Activity in the System «Driver – Car – Road – Environment»

Viktor Dolya, Ivetta Afanasieva, Urii Davidich, Iryna Englezi, Nizami Gyulyev, Oleksii Prasolenko

O. M. Beketov National University of Urban Economy in Kharkiv
Kharkiv, 61002, Ukraine

ABSTRACT

The article deals with the impact of information flows on results of the driver's activity in the system «driver – car – road – environment». Existing research on the impact of information flows on the characteristics of the driver are analyzed in this paper. It is determined that the previous studies do not study sufficiently the impact of information obtained from the additional sources (bill-boards on the side of roads, cell phones etc.) on the activity of the driver and do not research time of driver's distraction from performing main activities. As a result of laboratory studies the mathematical model of the impact of information flows based simultaneously on indicators of Electroencephalography (EEG) and EEG and ECG of time of driver's distraction from performing main activities is formed. Correlations of impact of information obtained from additional sources on time of driver's distraction from performing of main activity are received. Statistical evaluations of the obtained models demonstrate their adequacy and possible implementations.

Keywords: information flow, functional state, a driver, distraction.

INTRODUCTION

Any modern human faces with a problem of choice and processing of information coming to him/her in the age of information breakthrough. Human activity in systems "driver - car - road - environment" - is not an exception. The role and importance of information in all spheres of human activity increased significantly. The intensity of the flow of information that affects the person (a driver), is increasing constantly due to the rapid development of modern facilities of electronic telecommunications, increasing the number of roadside advertising, active use of cellular devices of information transmission. Increasing the flow of information both outside the car (excess unwanted information, the number of roadside advertising) and inside the car (using of the cellular and radio), affects the emotional state of the driver and reduces its reaction, increases the likelihood of traffic accidents (TA). Most accidents are caused by drivers, not by the car or by the road. The personal factor - the human psyche is the base of accidents. Taking into account this matter, the study of the impact of information flows on the driver is relevant.

METHODS USED IN RESEARCHES OF THE EFFECT OF INFORMATION FLOW ON THE DRIVER

Information flows

Directions for improving the organization of work of the drivers are based on the drivers' psychophysiological opportunities and their ability to receive information quickly and to act in stressful situations accurately, ie taking into account the driver's reaction time (Davidich, 2006). Furthermore, that directions are composed of control information transmitting to drivers tools. Effect of road conditions and information traffic in the human body causes fatigue and increases reaction time , decreased speed of information processing , ie, information overload the driver.

https://openaccess.cms-conferences.org/#/publications/book/978-1-4951-2098-5

Research on the influence of information flow on the characteristics of driver activities always attract attention because it affects the security of the person. In this paper we consider the influence of information obtained from other sources (billboards on the roadside, cell phones, etc.). All this led to the goal and objectives of the study.

Methods

There are many methods for studying human factors in systems (Charlton, 2002). During the investigation the most informative parameters of the impact of information flows on the performance of the driver in the system were chosen. The parameters were decided to be determined using the following methods: the method of EEG (Gnezditskiy, 2002) with using the hardware-software complex "Neurocom" (CSE., 2008), used to determine changes in the electrical activity of the driver's brain when processing the input information, the method of ECG (Akselrod, 2010) with using the hardware-software complex "Cardiosens" used to determine the level of driver fatigue in research; tabular method "correction test" used to determine the execution time of a driver distraction core activities.

STUDY OF INFORMATION FLOWS

On the road, every driver is faced with a huge amount of information flows (Fig. 1), in the present work we investigated the influence of information obtained from other sources.

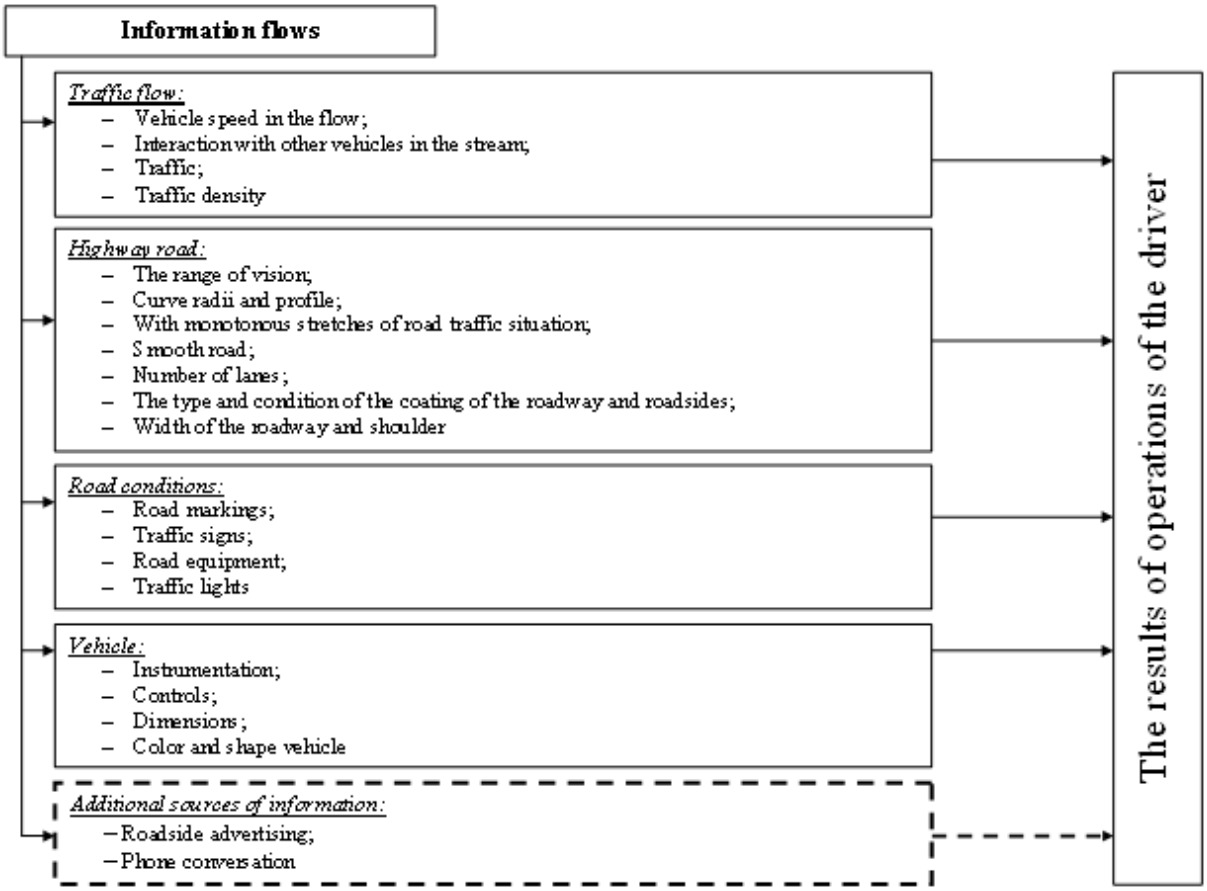

Fig. 1. Sources of information affecting performance of a driver

Study the impact of information flows on the performance of the driver consisted of two parts: laboratory studies and field studies. The first part (studding the impact of information flows on the performance of the operator) was carried out in the laboratory by the algorithm (Fig. 2).

The study was conducted in the laboratory under natural light. During the experiment the testee held a comfortable position. Small electrodes connected by wires to an electroencephalograph were attached with a special helmet to

the testee's head. Before starting the experiment, the testee was informed about the procedure of EEG and its painless. EEG brain research carried out for 20-30 min to obtain reliable data.

During the first stage (Fig. 2) the conditions of the laboratory experiment using an electroencephalograph, when the quantity of artifacts (N_{apr}) tends to a minimum are defined. Recommendations to reduce artifacts during laboratory studies are shown in the Table. 1.

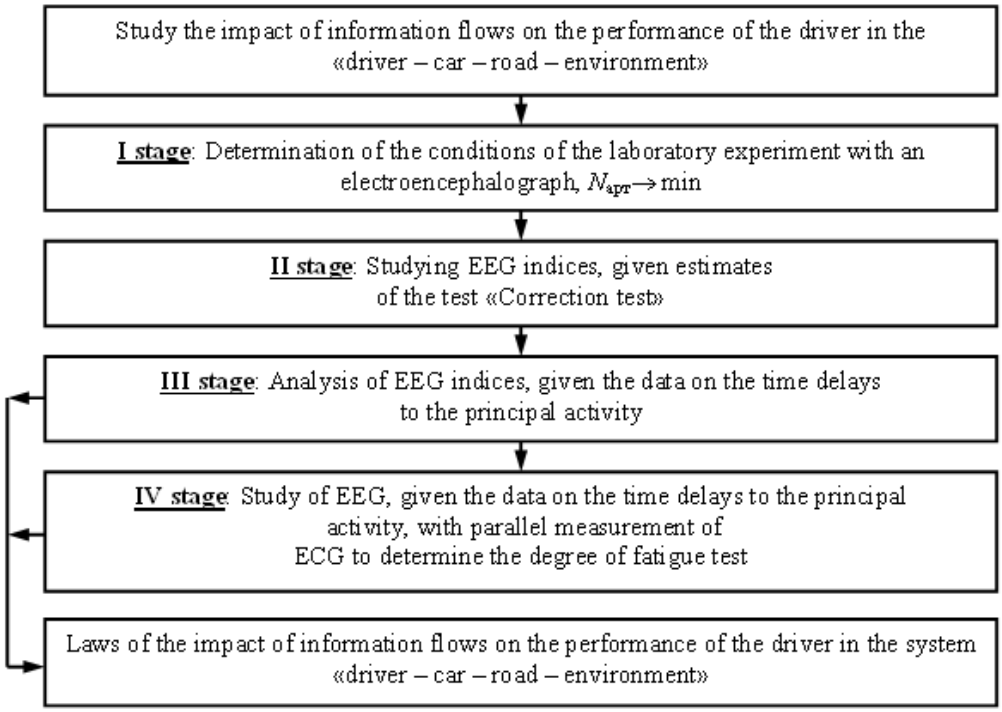

Fig. 2. Stages of the research

Table 1

Recommendations for reducing artifacts in laboratory studies using EEG

View artifact	The cause of	Recommendations to reduce its impact
Muscle artifact	Muscle activity (body motion test)	• Before starting the experiment, the subject must take a comfortable position; • During the experiment the test legs should be fixed, smooth head movement is possible in case of need under the experimental conditions; • Movement of the hands at the maximum possible limitation of motion of the forearm
Oculographical artifact	The rotation of the optic apple and winking test	• Before starting the experiment, the subject is able to use eye drops to moisten; • Using the occipital leads (O) for the analysis of EEG data; • Removal of visual artifacts using the technology ICA
Cardio artifact	ECG signal is close to the testee	• Conclusion of the experiment to the member whose registered this artifact
Pulsation artifact	Application of EEG electrode on a blood vessel of the testee	• Adjustment of the electrodes
Spiro artifact	Breath test	• During the experiment, the subject must breathe slowly;
Galvanic skin artifact	Sweating skin test	• Alcohol treatment places electrodes fixation
Voicekinetic artifact	Voice signals test	• During the experiment, the testee must speak without the use of abrupt facial movements
Extraphysiological artifact	Poor contact, AC, movement of objects around the subject, the sound wave directed at EEG amplifier	• Checking technical conditions before the start of the experiment; • Traffic technicians resolved within a 2 m, provided the use of rubber-soled shoes; • Do not direct sound wave from any source to the amplifier EEG

During the second stage the existence of the correlation between EEG and indicators of psychological test " correction test" was registered. The study involved 12 men aged 20-30 years. EEG recording of the test carried out in a state of quiet observation with open eyes. Monopolar recording was carried out in the 0-70 Hz bandwidth with a sampling frequency of 250 Hz with 19 active electrodes. Recording duration of the test was limited to complaints in the area of EEG and mounting hardware was 20 min. Estimates of test "correction test" indicate that an excess of information (additional questions) affects the development of fatigue during the experiment. However, these figures do not take into account the change in the amount of perceived information in real time. Taking into account the above mentioned items, the third phase of the study determined the correlation between EEG and delay processing of the information obtained during the test run its core activities due to the distraction of getting information from secondary sources.

During the third stage of the experiment, the testee must perform the test focused "correction test" , that was the main activities and main source of information obtained through the visual analyzer test . Simultaneously with this task subject received related to the main activity information from another source. One of the important tasks in the study - the right to answer the questions posed in the form of oral examples for easy mathematical calculation consists of two steps without being distracted from his main task - the test run " correction test." During this experiment was conducted surveillance of the work of the testee, by which time it was recorded distraction from performing basic activities.

Temporary sites were selected in each sample in order to analyze EEG data, corresponding to the time of distraction from the main activity of the test run . Time distraction was determined using a video of each sample and represents the time during which the subject ceased to perform its main function (passing the test " proof- test") , ignoring the questions.

Based on the analysis of quantitative characteristics of the intensity of the fast (β, γ) (Dolya et al., 2011) and slow (δ, θ) (Dolya et al., 2011) EEG rhythms constructed a general model of the impact of information flows that appears EEG , at the time of driver's distraction from performing its principal activity is as follows:

$$\Delta\tau_{м1} = 2,733 + 0,0423 \cdot \delta + 0,0295 \cdot \theta - 0,039 \cdot \beta - 0,018 \cdot \gamma, \quad (1)$$

$\Delta\tau_{м1}$ – while diverting drivers from performing their primary type of activity reflected EEG.

The results of calculations of the model parameters are given in Table 2 , the statistical evaluation of the model - in Table 3 . The resulting Fisher criterion (Table 3) shows the influence of informative model of information flows . Multiple correlation coefficient reflects a high degree of closeness of the connection. Assessment of the adequacy of the resulting model (1) was carried out in terms of average error of approximation, the value of which is equal to 10.86 %, which corresponds with the limits and indicates the adequacy of the model.

Table 2

Statistical evaluation of the general model of the information flows impact on the time of driver distraction from the main activity, considering the performance of EEG

Data	Values			
Factor	Percent delta-rate signal from the total power of the signal in the cerebral cortex	Percent theta-rate signal from the total power of the signal in the cerebral cortex	Percent beta-rate signal from the total power of the signal in the cerebral cortex	The percentage of gamma-rate signal from the total power of the signal in the cerebral cortex
Designation, dimension	δ, %	θ, %	β, %	γ, %
Coefficient	0,0423	0,0295	-0,039	-0,018
Standard error	0,329	0,0056	0,009	0,004
Student's *t*-test: calculated tabular	 8,296 1,98	 7,613 1,98	 3,184 1,98	 -9,639 1,98

In the fourth stage of the research organization of an experiment carried out in the same manner as in the third stage, with the additional use of hardware and software "Cardiosens." At this stage our task

was to determine the degree of operator fatigue, there are different methods for determining fatigue (Oven, 2009; Mocco, 2010). In our studies, we used the method allows the ECG in real time to determine the degree of fatigue.

Table 3

The results of assessment of the overall impact of the model information flows at the time of driver's distraction from the main activity, taking into account indicators

Data		Values
Multiple correlation coefficient, %		90,86
The average error of approximation, %		10,86
Fisher's exact test:	settlement tabular	241,04 2,46

The mathematical model of the impact of information flows was built based on analysis of the data obtained during the fourth step, taking into account the performance of EEG and ECG at the time of the driver's distraction from performing basic activities:

$$\Delta\tau_{M2} = (5,302 + 0,0899 \cdot \delta + 0,052 \cdot \theta - 0,0721 \cdot \beta - 0,055 \cdot \gamma)\left(\frac{P_r}{P_n}\right) P_{r^{\square\left(1-\frac{P_r}{P_n}\right)}}, \quad (2)$$

$\Delta\tau_{M2}$ – while diverting drivers from doing their core business, reflected EEG and ECG;

P_r – value of the index activity of regulatory systems in the billing period;

P_n – value of the index activity of the regulatory systems of the background sample.

The results of calculations of the model parameters are given in Table 4, the statistical evaluation of the model - in Table 5.

Table 4

Statistical evaluation of the general model of the impact of information flows at the time of driver's distraction from the main activity, considering the performance of EEG and ECG

Data	Values				
Designation, dimension	$\left(\frac{P_r}{P_n}\right) P_{r^{\square\left(1-\frac{P_r}{P_n}\right)}}$	$\delta \cdot \left(\frac{P_r}{P_n}\right) P_{r^{\square\left(1-\frac{P_r}{P_n}\right)}}$	$\theta \cdot \left(\frac{P_r}{P_n}\right) P_{r^{\square\left(1-\frac{P_r}{P_n}\right)}}$	$\beta \cdot \left(\frac{P_r}{P_n}\right) P_{r^{\square\left(1-\frac{P_r}{P_n}\right)}}$	$\gamma \cdot \left(\frac{P_r}{P_n}\right) P_{r^{\square\left(1-\frac{P_r}{P_n}\right)}}$
Coefficient	5,302	0,0899	0,052	-0,0721	-0,055
Standard error	0,714	0,011	0,018	0,008	0,009
Student's t-test: calculated tabular	 7,42167 1,98	 8,34781 1,98	 2,8517 1,98	 -8,6942 1,98	 -6,4535 1,98

Table 5

The results of assessment of the overall impact of the model information flows at the time of driver distraction from the main activity, considering the performance of EEG and ECG

Data		Values
Multiple correlation coefficient, %		99,11
The average error of approximation, %		9,32
Fisher's exact test:	settlement tabular	913,1 2,46

Based on the data shown in Table 5, its calculated Fisher criterion more table index, which indicates the informative model. Meaning of the multiple correlation coefficient is 0.99, which reflects the high quality

features and the coupling strength indicates that , through the use of a comprehensive registration and evaluation of ECG and EEG indicators was obtained more qualitative mathematical model to determine the influence of information flows at the time of distraction from performing drivers to their main activity . Average value of the approximation error for the model (2) is 9.32 %, which corresponds with the limits and indicates the adequacy of the model. Compared with the model (1), the value of the average error of approximation which is 10.86 % , we see that by incorporating ECG in the model (2) , managed to get a more accurate model of the impact of information flows at the time of driver distraction from performing its core activities. On the basis of the calculations can be concluded possibility of using the mathematical models (1, 2) in further studies.

The second part of the study was carried out in real conditions. The study involved 10 drivers aged 24 to 45 years with the experience from 6 to 12 years, excluding the type of temperament and gender of the driver.

In the first phase of this study was determined by the possibility of electrophysiological studies of EEG and ECG in natural conditions. Was chosen for two vehicles with different transmissions : a manual and automatic . The purpose of this phase of the study - to identify all possible artifacts in the equipment for recording EEG and ECG signals. For this experiment was chosen route traffic on the ring road of the city of Kharkiv .In the laboratory, the subject was fixed electrodes Holter "Cardiosens" electroencephalograph electrodes fixation " Neyrocom " (Fig. 3)carried out in the car, which was parked in an authorized location at the beginning portion of the selected route.

Fig. 3 Fixing electrodes

The experiment led to the following conclusions:

1) bumps in the road affect the quality of the recording EEG and ECG signals, creating strong interference in the record. In view of this route in the route selection for further experiments must take into account the quality of the pavement;
2) impact of the use of vehicles with different transmissions: a manual and automatic. While driving using a manual transmission driver performs a plurality of mobile functions, preventing the recording of EEG and ECG signals. In order to avoid additional sources of interference in further experiments will use cars with automatic transmission;
3) while driving in conditions of quality pavement to minimize muscle movements driver may write quality signal EEG and ECG.

Fig. 4 types of outlets video

During the second stage of the study conducted experiments in natural conditions in different parts of the roads within the Kharkiv city, and on the roads at the entrance to Kharkiv in areas with a high density of roadside advertising (billboards). Investigated the effects of additional sources of information (billboards , telephone calls using the system BLUETOOTH HANDS FREE, music and radio in the car) on the driver with the definition of the time delay in getting information from the primary source (road conditions). Subjects drivers before entering the route has been focused on research and on the experimental vehicle. The test drivers in this study controlled car equipped with two cameras to remove the review and removal of front face of the test (Fig. 4).

For analysis of data 45 studies 10 and portions with a total collection time of 15 hours were obtained. Total 90 videos were analyzed and identified 121 cases of identifying additional sources of influence on the driver.
Influence of information obtained from a telephone conversation on the location in the field of vision prominent advertising (additional sources) on driver distraction from the road conditions (mandatory information source) was determined taking into account the resulting model (2). Using the model, the impact of information flows at the time of distraction from performance drivers of their main activity (2), the dependences shown in Fig. 5.

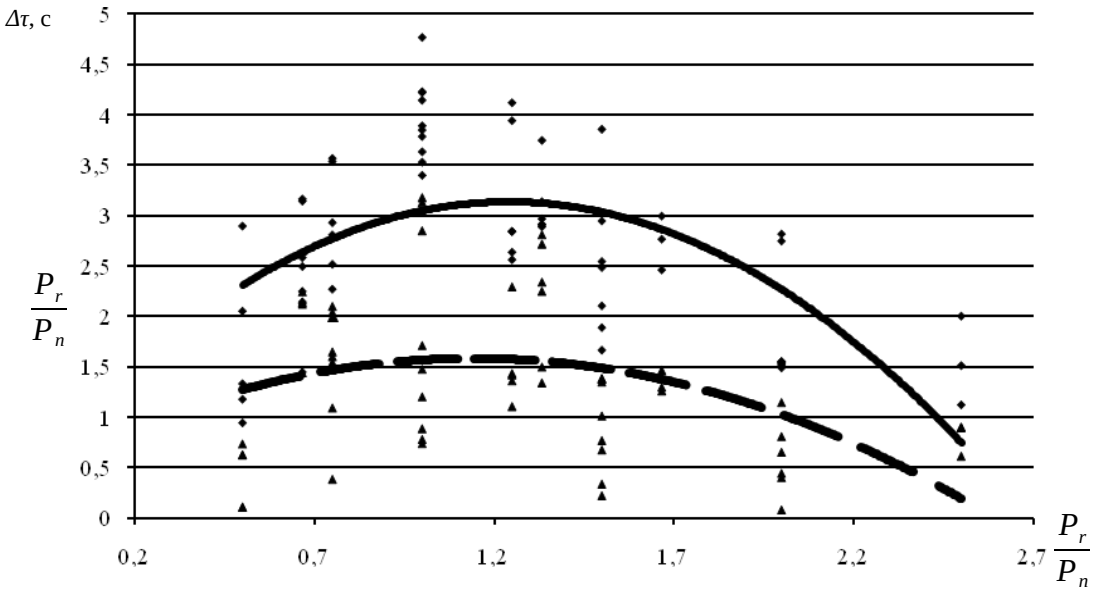

Fig. 5. Dependence on the time change of driver's distraction from performing basic activities in view of its functional state when the information obtained from the telephone conversation and roadside advertising:

- The impact of the telephone conversation;
- The impact of off-road advertising.

The resulting curve (Fig. 5) suggests that after the core business and increase driver's fatigue during the distraction of additional sources of information decreases. This is due to the fact that the driver is focused on the treatment of the basic information from the road and the environment. These dependences show that the additional information obtained from a telephone conversation when the driver core activities , distracting him twice as much as the information that the driver receives from roadside advertising.

CONCLUSIONS

As a result of studding the influence of additional sources of information on the time of driver's distraction from the main activity was determined that the information flow because of the driver's conversation by phone with the use of BLUETOOTH HANDS FREE distracts the driver from 0.94 s. to 4.77 s.

Information flows arising from the location in the field of driver's vision prominent advertising while driving distracted him/her from performing basic activities from 0.23 s. to 2.81 s. results of influence of the telephone conversation and roadside advertising on the driver were obtained in this study, but in general this method of research conducting lets to determine the impact of any sources of information, such as music , radio , passengers in the car , etc. on a driver or operator of any system .

REFERENCES

Давідіч Ю. О. (2006), *Проектування автотранспортних технологічних процесів з урахуванням психофізіології водія* – Х. : ХНАДУ. – 292 с.

Charlton S. G. *Handbook of human factors testing and evaluation* – Mahwah : LEA. – 2002. – p.536. – 2nd. Edition.

Гнездицкий В. В. (2002), *Обратная задача ЭЭГ и клиническая электроэнцефалография* – Таганрог: ТРГУ. – 625 с.

Компьютерная система электроэнцефалографии НейроКом : инструкция по эксплуатации. – Х.: НФУ «ХАИ», 2008. – 171 с.

Аксельрод А.С. (2010), *Холтеровское мониторирование ЭКГ: возможности, трудности, ошибки* – 2-е изд., исправ. и доп. – М.: МИА,. – 192 с.

Доля В. К., Енглезі І. П. , Афанасьєва І. А. (2011), *Вплив інформаційного навантаження на параметри основної діяльності водіїв (гальмівні процеси)* // Інформаційно-керуючі системи на залізничному транспорті. – № 3. – С. 32–35.

Доля В. К., Енглезі І. П. , Афанасьєва І. А. (2011), *Вплив інформаційного навантаження на параметри основної діяльності водіїв (збуджувальні процеси)* // Восточно-европейский журнал передовых технологий. – 1/2(49). – С. 65–68.

Oven S. *Survey and evaluation of fatigue assessment software [Електронний ресурс] / Project, Fall. − 2009. – p. 30. − Website: http://www.utmis.org/sv/aktuellt/Documents/Oven_Project (2).pdf*

Моссо А. *Усталость. Физиологические и психологические аспекты/ А. Моссо. / Пер. с итал. − Изд. 2 − М. : ЛКИ, 2010. – 328 с.*