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Application of the study of bioelectric brain activity to assess the level of drivers' attention

Streszczenie. *Celem badań była analiza uwagi u kierowców zawodowych, podczas wykonywania przez nich codziennych obowiązków służbowych. Zakres prac obejmował badanie poziomu sygnałów EEG u dwóch kierowców podczas jazdy i manewrów związanych z transportem ładunku (tj. podczas wykonywania zleconych im obowiązków służbowych). Sygnały EEG kierowców zostały przetestowane za pomocą neurohełmu Emotiv Insight. Badanie wykonywano przez dwa kolejne dni pracy każdego z kierowców, w dwóch porach dnia, a zarejestrowane sygnały EEG posłużyły do analizy poziomu skupienia uwagi. (**Zastosowanie badania bioelektrycznej aktywności mózgu do oceny poziomu uwagi kierowców**)*

Abstract. *The aim of the study was to analyze the attention of professional drivers while performing their daily duties. The scope of work included examining the level of EEG signals in two drivers during driving and maneuvers related to the transport of cargo (i.e. while performing their official duties). Drivers' EEG signals were tested using the Emotiv Insight neurohelmet. The test was performed on two consecutive working days of each driver, at two times of the day, and the recorded EEG signals were used to analyze the level of attention.*

Słowa kluczowe: elektroencefalografia, bioelektryczna aktywność mózgu, neurohełm, zaangażowanie uwagi
Keywords: electroencephalography, bioelectrical brain activity, neurohelmet, attention involvement

1. Introduction

Transport is one of the main branches of the modern economy. It is also the basis for the process of internal and external integration, which is conducive to employment and economic growth [1]. The role of transport is based on the transport of people and cargo, which contributes to its complementarity with other branches of the economy [2]. For this reason, its proper organization, infrastructure and staff are so important.

The work of a driver is associated with great responsibility, consisting in constant participation in transport traffic. Each professional driver is responsible for his own safety, the safety of other road users and the condition of the transported load. The efficient course of work depends on the degree of concentration of attention, its divisibility, shifting and durability [3]. Therefore, this profession requires the driver to constantly concentrate on the surroundings, the condition of the roads, other vehicles and the behavior of other road users. The focus (concentration) of attention means the selection of appropriate stimuli from the "stream of consciousness" so that effective functioning is possible [6]. It also determines the level of activity of specific cognitive processes in the task being performed [7], which allows for the selection of this content from the "stream of consciousness" and enables effective action based on this content. Mental burden here results not only from the growing amount of information, but also from the need to skilfully decode it [4]. An important aspect of the driver's work is also the phenomenon of monotony and its effects, especially the decrease in work efficiency and the increasing number of errors [5].

The conducted research was aimed at checking the possibility of controlling the level of concentration of attention of professional drivers driving a truck tractor with a self-unloading semi-trailer while driving to the place of loading, the loading process, and access to the place of loading. unloading and during unloading by electroencephalographic methods.

2. Aim and scope of research

The aim of the study was to analyze selected cognitive states (i.e. the level of commitment and attention) in professional drivers while performing their daily duties.

The scope of the work included the study of EEG signals in two drivers while driving and maneuvering related to the transport of cargo (i.e. while performing their official duties). The test was performed on two consecutive working days of each driver, at two times of the day, and the recorded EEG signals were used to analyze the level of attention. The tests were carried out while driving on a fixed route, while driving trucks (a truck tractor with a self-dumping semi-trailer).

Cognitive and utilitarian justification of the research goal:

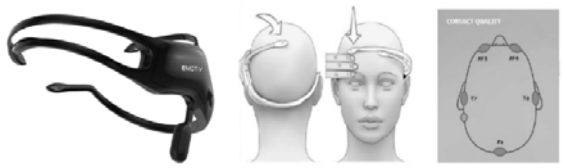
It seems that monitoring the variability of the level of attention of drivers can detect a constant moment of lowering the concentration of this attention, which can contribute to the correction of the work schedule and, consequently, increase the employee's efficiency and road safety.

The cognitive objective of the study was to check how the level of attention of professional drivers develops while performing activities known to them.

3. Research methodology

The research was conducted among employees of a transport company operating in Krakow. The drivers selected for the study are men of various ages and professional experience:

• driver no. 1 - age: 35 years, work experience: 14 years;
• driver no. 2 - age: 47 years, professional experience: 25 years;



a b

Fig. 1. a - Emotiv Insight neurohelmet, b - electrode arrangement diagram on the head, Source: https://www.emotiv.com/epoc-flex/

The study was conducted during the daily work of drivers. The study included the following stages: driving to the place of loading, loading, driving to the place of unloading and unloading. Each time, the driver's route was about 30 kilometers, and all stages of one test lasted a total of about 70 minutes. The transported goods were aggregate, loose material with a grain size of 8 - 16 mm. The load capacity of each semi-trailer was 27 t. While driving, each driver wore an Emotiv Insight neurohelmet (fig. 1a).

The software cooperating with the apparatus enables control of the quality of the signal recorded by each electrode, observation of the EEG signal coming from the electrodes (Fig. 1b) and the level of involvement of selected cognitive states (such as focusing attention on a task) and emotional states (such as frustration or excitement). The results of the research recorded in the form of a film were analyzed, determining the characteristics of changes in the level of attention of each driver at individual stages of work. The Insight device, which is referred to in the article as a neurohelmet, works like a simplified electroencephalograph. This means that its efficiency is lower than that of a standard, full-size electroencephalograph, but the wireless form of the apparatus allows it to be used in research outside the laboratory conditions, e.g. in the field. This advantage is very important from the point of view of the conducted research, because the wireless form of the apparatus allowed conducting research while driving along the designated route, on the road.

The examination begins with placing a band on the head of the examined person, on which electrodes are placed. Then, check whether the electrodes have been correctly placed on the subject's head (i.e. check connectivity). The software that works with the helmet allows you to control the quality of the signal recorded by each electrode. On one of the interfaces of the program, it is possible to display a sketch of the electrode arrangement Fig. 2.

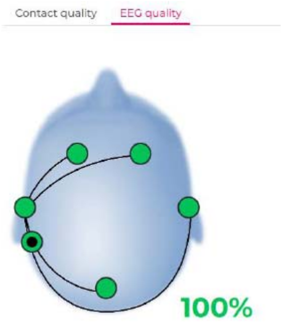


Fig. 2. A screenshot of the EmotivPRO app showing a map of electrode locations

After the electrodes have been properly connected, a proper EEG test was started. If the electrodes have good contact, you can proceed with a proper EEG study.
The result is presented in real time in the form of several different graphs. One of them is the classic electroencephalogram, presented for each electrode separately (Fig. 3).

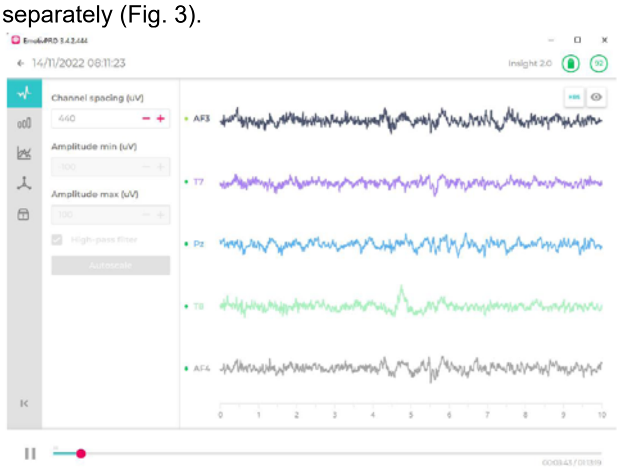


Fig. 3. A screenshot from the EmotivPRO application showing the recorded EEG signal

The next graph shows the registration of the level of involvement (in the program marked as power) of brain waves with specific frequencies. Thanks to this, we can see whether the waves responsible for concentration (like beta waves) or, for example, waves representing mental relaxation and meditation are involved to a greater extent (Fig.4).

Fig. 4. Screenshot from the EmotivPRO application showing brain wave activity

The next, third chart shows the level of involvement of individual emotional and cognitive states (Fig. 5).

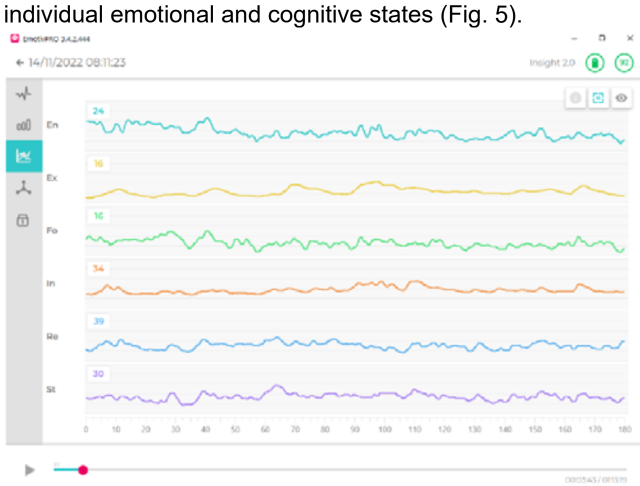


Fig. 5. Screenshot of the Emotiv application interface showing the recorded state record

Engagement (En) is vigilance and conscious focusing of attention on stimuli related to the task being performed. It is characterized by increased physiological arousal, beta waves and weak alpha waves. It works according to the following dependencies: the higher the workload, attention and focus, the higher the recorded level of involvement. Excitement (Ex) is the awareness or sensation of positive physiological arousal. It manifests e.g. through dilated pupils, eyes or activation of sweat glands. Focus (Fo) is a measure of the depth of concentration of attention on one task and the frequency of switching between tasks.
Interest (In) is a measure of attraction or aversion to a current stimulus, activity, or environment. A low level of interest indicates reluctance to perform the task, a high level of strong kinship, and a medium level of indifference towards the task. Relax (Re) indicates the ability to switch off and recover from increased focus. Stress (S) means the degree of comfort towards the task being performed, and its high level occurs e.g. through the inability to complete the task and the negative consequences associated with it (Emotiv).

3.1. Calibration

The study of attention with the use of an electroencephalograph may be burdened with a large error and inaccuracy in the analysis of the results. In order to reduce the risk of their occurrence, the measurement system was calibrated [8]. Calibration of the measurement system is possible thanks to the EmotivBCI application, in which it is possible to record facial expression data streams on one of the screens.

After putting on the neurohelmet, the tested person performs subsequent tasks related to the appropriate facial expressions. Each exercise is recorded for 8 seconds. These include: neutral facial expression, smiling, frowning brows, clenched teeth, raised eyebrows. Figure 13 shows a screenshot from the EmotivBCI app while capturing a smile

3.2. Conversion of results

The Emotiv software allows you to save the measurements as files with the .edf2 extension. EEG graphs are also saved in a numerical format that can be reproduced in an MS Excel spreadsheet [8]. It also gives you the ability to record the level of cognitive states, where each second corresponds to the result of the level of individual performance indicators. Engagement and attention charts are scaled to a maximum value of 1 and a minimum value of 0. The value of individual indicators is therefore expressed numerically and is within the <0;1> range. In this way, a dataset was created in which values corresponding to the levels of cognitive states were determined for each second of measurement [9].

4. Research findings and their analysis

An EEG study was carried out using the EMOTIV INSIGHT device in two professional drivers, while driving with a load, without a load and during the loading and unloading process. The recorded course of the study was recorded in numerical form, from which graphs were then created. The collected data were presented in the form of characteristics showing the level of individual performance indicators (engagement and focus) during the study from two measurements. Their course was analyzed, comparing the results from individual stages (access to loading, loading, access to unloading, unloading) from both days and activity indicators. A comparison was also made between the individual stages of the study for each driver. In order to clearly present the achieved results and perform a thorough analysis, the average and standard deviation for each of the measurements were determined.

The research conducted for the purposes of this paper focused on the analysis of the level of focus and attention engagement. The graphs obtained as a result of the study present the results of focusing attention separately for each driver, separately for each of the activities separated in the methodology. An exemplary graph is shown in Figure 6. It shows the level of attention during unloading of driver no. 1 in a row of two working days.

The ordinate (y) axis indicates the level of activity indicators (engagement or focus) and the abscissa (x) indicates the time of the study measurement.

Driver No. 1, access to the place of loading:

The average level of attention during the measurement on the first day was 0.42 with a standard deviation of 0.1, while on the second day the mean was 0.44 with a standard deviation of 0.19. The average level of attention during this measurement on day one was 0.33 with a standard deviation of 0.12, while on day two the mean was 0.27 with a standard deviation of 0.16. While recording the signals, the authors recorded their observations, which show that the greatest deviations occurred at the moments of maneuvering (intersections, roundabouts), and a temporary increase in attention - when approaching a pedestrian crossing. The second day was characterized by a greater range of results. The driver engaged more attention in the second part of the study, when driving through towns with narrower roads. Thus, the focus while driving changed depending on the driving conditions. The increase was due to sudden stimuli, such as noticing a pedestrian on the roadside, as well as in places where the driver had to perform other tasks than driving on a straight road. In the survey, driver no. 1 indicated that during each of the examinations he felt well rested, did not feel tired, was healthy and did not take drugs or other substances that could affect cognitive functions.

Driver No. 1, loading:

The average level of attention during this measurement on day one is 0.44 with a standard deviation of 0.12, while on day two the average was 0.52 with a standard deviation of 0.13. The average level of attention during this measurement on day one is 0.33 with a standard deviation of 0.11, while on day two the average was 0.36 with a standard deviation of 0.12. The measurements were characterized by a similar deviation of the results. The first day is characterized by spikes in attention engagement caused by waiting for loading.

Driver No. 1, access to the place of unloading:

The average level of attention during this measurement on day one is 0.45 with a standard deviation of 0.13, while on day two the average was 0.48 with a standard deviation of 0.16. The average level of attention during this measurement on day one is 0.33 with a standard deviation of 0.15, while on day two the average was 0.33 with a standard deviation of 0.16. The characteristics of involvement and attention were similar when driving with a load. This shows the relationship between these indicators.

Driver No. 1, unloading:

The average level of attention during this measurement on day one is 0.44 with a standard deviation of 0.15, while on day two the average was 0.53 with a standard deviation of 0.1. The average level of attention during this measurement on day one is 0.33 with a standard deviation of 0.15, while on day two the average was 0.41 with a standard deviation of 0.09. The unloading process consisted of driving to the appropriate storage place, unloading the aggregate and leaving the yard. On the first day, the unloading yard was empty, while during the measurement no. 2, there were a dozen or so employees on it, thanks to which the driver's attention was kept at a high level. The characteristics of focusing attention during unloading are similar to the course of engagement.

Driver No. 2, access to the place of loading:

The average level of attention during this measurement on day one is 0.46 with a standard deviation of 0.13, while on day two the average was 0.45 with a standard deviation of 0.16. The range of results during the tests during the first measurement was in the range <0.06; 0.89> and in the second <0.04; 0.84>. The average level of attention during this measurement on day one is 0.31 with a standard deviation of 0.15, while on day two the average was 0.30 with a standard deviation of 0.13. While driving, due to the need to frequently switch between tasks and a large number of stimuli, both focus and attention of the driver no. 2 was dynamically changing.

In the survey, driver no. 2 indicated that during each of the examinations he felt well rested, did not feel tired, was healthy and did not take drugs or other substances that could affect cognitive functions.

Driver No. 2, loading:

The average level of attention during this measurement on day one is 0.34 with a standard deviation of 0.17, while on day two the average was 0.55 with a standard deviation of 0.17. Range of results in the engagement measurement no. 1 is <0.02; 0.87> and in the second <0.05; 0.96>. The average level of attention during this measurement on day one is 0.21 with a standard deviation of 0.15, while on day two the average was 0.36 with a standard deviation of 0.17. On the second day, there were a dozen or so employees at the loading yard, which could increase the driver's attention

Driver No. 2, access to the place of unloading:

The average level of attention during this measurement on day one is 0.38 with a standard deviation of 0.14, while on day two the average was 0.50 with a standard deviation of 0.2. Range of results in measurement no. 1 is <0.05; 0.94> and in the second <0.02; 0.89>. The average level of attention during this measurement on day one is 0.27 with a standard deviation of 0.17, while on day two the average was 0.32 with a standard deviation of 0.17. The commitment graph is characterized by high volatility in short time intervals.

Driver No. 2, unloading:

The average level of attention during this measurement on day one is 0.44 with a standard deviation of 0.13, while on day two the average was 0.43 with a standard deviation of 0.17. Range of results in measurement no. 1 is <0.09; 0.78> and in the second <0.07; 0.72>. The average level of attention during this measurement on day one is 0.34 with a standard deviation of 0.13, while on day two the average was 0.38 with a standard deviation of 0.15. Attention level during measurement no. 2 increased at the end of the study, due to the difficult exit from the unloading yard.

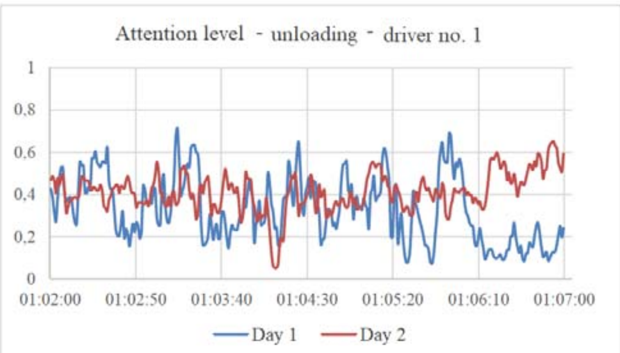


Fig. 6. Attention level when unloading driver no. 1 in a row of two working days

5. Summary and conclusions

Research was carried out on the activity of the cerebral cortex in two professional drivers while performing the tasks entrusted to them, including driving with and without a load, as well as the process of loading and unloading. The results of the measurements of activity indicators were analyzed. In particular, attention was paid to engagement, which indicates vigilance and conscious attention to task-related stimuli. The greater the attention, focus, and workload, the higher the recorded engagement score. The level of focus, which is a measure of concentration of attention on one specific task, was also analyzed. High levels of task switching indicate poor concentration and distraction. Based on the analysis of the conducted research, it was found that:

1st driver no. 1 achieved a higher level of commitment and attention while performing tasks related to loading and unloading activities than while driving;

2nd level of driver's attention involvement no. 2 was much higher during the measurement on the second day in each of the stages of the study (the way to the place of loading, loading, the way to the place of unloading, unloading);

3. high variability in the level of both cognitive states in drivers may result from engaging attention in various stimuli. In order to perform a more accurate analysis, the apparatus should be calibrated individually for each driver and each activity (e.g. by measuring the level of cognitive state during the maximum concentration declared by the driver on the selected activity).

The conducted study may be the basis for confirming the assumption about the need to control the cognitive states of professional drivers. By increasing the size of the research group and subjecting it to repeated trials, it will be possible to select the appropriate driver working time and breaks in order to increase road safety and reduce the level of mental workload. This profession is associated with great responsibility, which is related to the safety of the driver himself, other traffic participants, as well as the transported cargo. Mental fatigue caused by too many stimuli has a negative effect on concentration on the task at hand. A high level of concentration allows you to assess and react quickly about the traffic situation.

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REFERENCES

[1] Bylinko L. (2018). Znaczenie transportu w gospodarce. Scientific Publishing House of the University of Technology and Humanities in Bielsko-Biała

[2] Rola transportu w gospodarce (online). Obtained from: https://nowagazeta.pl/artykul/rola-transportu-w-gospodarce/893551, access: 15.01.2023r.

[3] Olszewski J. (1997). Podstawy ergonomii i fizjologii pracy. Publishing house of the Poznań University of Economics;

[4] Złowodzki M., Juliszewski T. (2011). Ergonomia wobec obciążeń praca umysłową. Obciążenie psychiczne pracą - nowe wyzwania dla ergonomii. Committee of Ergonomics of the Polish Academy of Sciences, Cracow, pp. 7-20

[5] Kruszewska X. (2021). Monotonia pracy – czym grozi? Obtained from: https://zdrowiewpracy.pl/profilaktyka/monotonia-pracy-czym-grozi/, access: 15.01.2023;

[6] Asanowicz D. (2019). Funkcjonowanie uwagi i jej wpływ na inne procesy umysłowe - Autoreferat. Obtained from: https://phils.uj.edu.pl/documents/41606/144117662/asanowicz_autoreforat.pdf/4aecd5c9-1937-4f1d-b546-ef4df34b29b2, access: 10.01.2023;

[7] Francuz P. (2000). Mechanizm uwagi: przegląd zagadnień w perspektywie psychologicznej i neurofizjologicznej. Publishing House Zysk i S-ka, Poznan

[8] Jankowska A. (2020). Badanie poziomu wybranych stanów emocjonalnych u pracowników biurowych. Master's thesis carried out under the supervision of dr. Eng. Karolina Trzyniec at the University of Agriculture in Krakow;

[9] Jania A. (2021). Wpływ stresu na poziom koncentracji uwagi kierowców. Engineering Thesis carried out under the supervision of dr. Eng. Karolina Trzyniec at the University of Agriculture in Krakow;