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THE PSYCHOPHYSIOLOGICAL DETERMINANTS OF PROFESSIONAL DRIVING SKILLS IN RELATION TO TRAFFIC SAFETY

Summary. In the paper the psychophysiological factors determining the ability to drive were characterized. The present methods of assessment of the basic driver's physiological parameters were described and also the measurement methods, currently used in work medicine were presented. Additionally, the possibilities of the assessment of the psychophysiological state of the driver, using currently available, hardware solution were shown.

PSYCHOFIZJOLOGICZNE UWARUNKOWANIA PRACY KIEROWCY W ASPEKCIE BEZPIECZEŃSTWA RUCHU DROGOWEGO

Streszczenie. W artykule scharakteryzowano uwarunkowania psychologiczno-fizjologiczne określające zdolność osoby do prowadzenia pojazdu. Opisano aktualne metody oceny podstawowych parametrów fizjologicznych kierowcy, jak również przedstawiono narzędzia pomiarowe obecnie stosowane w zakładach medycyny pracy. Dodatkowo wskazano na możliwości oceny stanu psychofizjologicznego osoby w czasie prowadzenia pojazdu, przy użyciu współcześnie dostępnych rozwiązań sprzętowych.

1. INTRODUCTION

The psychology and physiology of the professional driver's work as well as the non-professional driver are directly connected with traffic safety, in the broad sense. The psychomotor fitness and adequate qualifications of drivers determining the proper working of the transport processes minimize the social and economic losses.

The primary elements of evaluation of the individual's ability to drive are medical examinations, which are carried out among all candidates for drivers jobs. The type and scope of examination depends on driver's license category and on the form of referral. The additional criterion of driving ability's assessment is the psychotechnical examination carried out to state the existence or lack of psychological contraindications to driving. The subjects of the psychological examination are candidates for driving instructors, examiners and people who exceeded 24 penalty points or drove in the state of intoxication, or caused fatal road accident, and professional drivers.

From the point of view of driving time, distance covered and work character, professional drivers are the group particularly exposed to factors which negatively affect on the psychophysical state. According to normative acts, professional drivers are obliged to undergo periodical psychological examinations, periodical medical examination and to obey the norms of driving time.

Assessment procedures of ability to drive, mentioned above, have a static character, because they test only the actual state of a person. The complexity of the driver's work, difficult work conditions and the multitude of factors influencing the psychomotor state of a driver require implementation of instruments of online control, which would follow the dynamic of a driver's situation. The proposed real time control of driver's behaviors and reactions would support and complete the complex psychophysiological analysis of a driver job.

2. THE CURRENT METHODS OF ASSESSMENT OF DRIVER'S PSYCHOPHYSIOLOGICAL CONDITIONINGS

The current methods of a driver's psychophysiological conditionings assessment are medical examinations. These are obligatory for people, who applied for a driver's license, regardless of its category, and also in the case of proposal of the proper organ (control agency, examiner…). Moreover, according to the act of road transport from the 17th November 2006, a professional driver is subjected to medical examinations:

1) until the age of 60 – every 5 years,
2) after the age of 60 – every 30 months.

The main purpose of medical examinations is to judge the state of: the cardiovascular system, the respiratory system, the nervous system, organs of locomotion and psychological state. The evaluation of the organ of sight, organ of hearing and balance state in case of professional drivers consists in the control of the following parameters:

1) Organ of sight
   - the sharpness of vision for the better seeing eye not less than 0.8, for the second one not less than 0.5,
   - correction:
     - by the sharpness of vision for every eye at least 0.5,
     - glass correction or contact lenses, under the condition of good tolerance and correction adaptation
     - by the sharpness of vision for every eye under 0,5,
     - acceptable correction in range: ±4.0 Dsph , ±2.0 Dcyl,
     - acceptable anizometrophy: ±3.0 D,
   - color recognition – the proper recognition of yellow, red and green,
   - field of sight – proper
   - both eye sight – proper
   - night vision and sensitivity for dazzle – proper.
2) Organ of hearing
   - the candidate for a driver,
     - audibility of whisper by every ear separately at least from 6 m,
     - tonal audiogram - proper,
   - driver,
     - audibility of whisper by every ear separately at least from 3-4 m,
     - audiometric examination: 0.5-2kHz, a loss of hearing not more than 20 dB, above 2 kHz not more than 60 dB.
3) Organ of balance – in any case, full efficiency is required.

The enclosure of Health Minister's decree about drivers' and people applying for a driver's license medical examination, points the following way of carrying out the organ of hearing and balance examination:

- organ of hearing – testing of the hearing's sharpness is carried out separately for each ear. One ear is not active (it is executed by pressing it with a finger and rhythmical shaking of the ear auricle), whereas the doctor tests the second ear using proper words' combination. The hearing is considered as proper when the examined person is able to hear a whisper from a distance of six meters,

- organ of balance - testing the balance organ is carried out by gathering exact information about dizziness, ear diseases, hearing noises and ear operations. It is advisable to make a "Romberg and Fleck" test (standing on one foot with closed eyes for 15 seconds). In special cases it is necessary to take the electronystagmography test.

In case of psychological condition's evaluation of a driver, the psychotechnical examinations are applied. According to the act of road transport from the 17th November 2006, the professional driver is subjected to medical examinations:

1) until the age of 60 – every 5 years,
2) after the age of 60 – every 30 months.

The main purpose of these examinations is to judge the driver's personality's features as well as his intellectual and psychophysical fitness. Currently, in the laboratory, the following research tools are used:

- psychological tests – test with the object of temperament, personality and intellectual assessment of the examined driver (or a candidate for a driver),
- "apertachodometr" –an instrument designed to measure the abilities of objects' linear speed estimation and decision making time,
- Popelreuter tables –useful in estimation of the driver's co-ordination, attentions shift and dividing in the condition of time pressure ,
- reaction measuring instrument – a device designed to measure the speed and evenness of the psychophysical reaction on light and sound stimulation,
- cross–shaped measuring instrument ("aparat krzyżowy") – estimation of psychomotor reaction, sight and movement reaction, precision of perception and decision making time,
- "wirometr" – an instrument designed to test the estimation of an object's speed in road traffic,
- "stereometr" – an instrument designed to measure the driver's three-dimensional sighting which is essential to distance estimation,
- "Piórkowski" measuring instrument – a device applied to test the speed of the psychomotor reactions in the set of pace, sight and movement co-ordination and the ability of concentration.

The mentioned examinations are carried out by entitled psychologist in suitably adjusted laboratories.

As mentioned before, both medical as well as psychological examinations describe only the ability to drive a vehicle. These methods are not taking under consideration the dynamic changeable driver's work condition, which directly affects on his psychophysical condition. For this reason, the important issue in the driver's work safety analysis is the fatigue phenomenon, which is described in details in the next section.

3. THE PROBLEM OF DRIVER'S FATIGUE

According to the definition, fatigue is described as a temporal reduction of the ability to work, that results from working or from the changes that occur in the organism. The fatigue is a natural organism's protection against intensive or long-lasting work. In case of drivers, dr Anna Łuczak and dr Krystyna Żużewicz from the Central Institute of Work Protection, point out the following types of fatigue, resulting from different fields of human activity:

- muscular – results from accumulation of the products of metabolism in the human body and also from the constant position of the body during driving a vehicle,
- sensory – means a reduced reactivity of sense organs, which results from long-lasting exposition on specific types of stimulus,
- mental – it results from long-lasting attention effort and from the monotony of the driving conditions,
- emotional – the bodies reaction on stress factors (time pressure etc.) [5].

The examinations carried out in Poland showed, that as a result of fatigue, the following driver's psychophysical coefficients are getting worse:

- reaction constancy,
- speed and range of perceptiveness,
- attention,
- reaction speed. [1].

As the author [3] stresses "*After eight hours of work the reaction time decreases in 26% and after sixteen hours even in 90%*". The graphs below show the number of traffic accidents in Poland in years 2006-2007, happening because of the driver's fatigue/falling asleep.

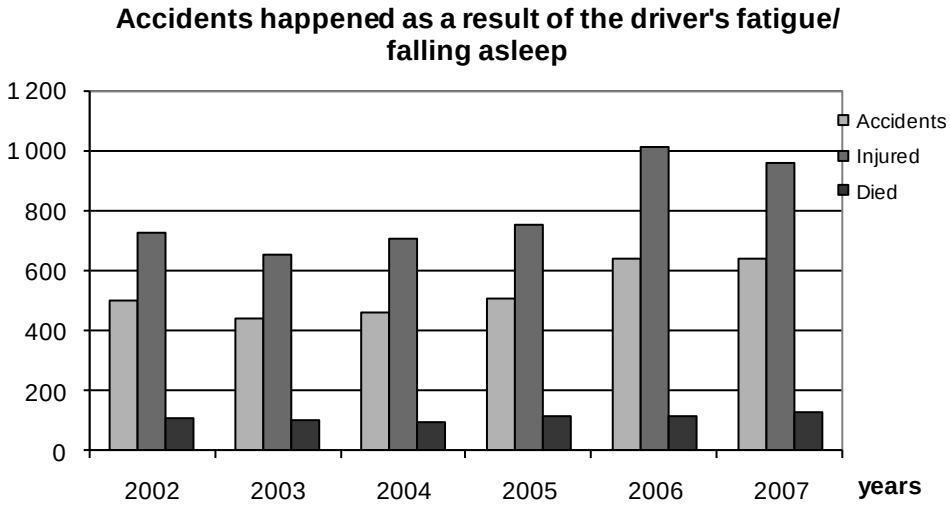

Fig. 1. Accidents happened as a result of the driver's fatigue/falling asleep (Source: Head Police Office)
Rys. 1. Wypadki powstałe na skutek zmęczenia/zaśnięcia kierowcy (Źródło: Komenda Główna Policji)

As it can be seen on Fig. 1, the number of accidents over the last few years has grown up to about 650 events during one year. As a result of fatigue/falling asleep every year almost 130 people die and about one thousand are wounded.

Analyzing the driver's fatigue process during driving it is worth paying attention on the ergonomics of his work. The ergonomics, as an interdisciplinary issue, plays a fundamental role in the process of keeping high the driver's psychophysical fitness. It consists in adapting the vehicle and the environment's conditions to the driver's work as well as in a proper selection of the driver to given activities. The purpose of ergonomic action is to increase the efficiency and the comfort and thus to increase the work's safety. From the point of view of ergonomics, the most important issues of adapting the vehicle to the driver's work include:

- steering elements,
- steering wheel (proper diameter, possibility of adjustment),
- pedals (location, distance),
- dashboard (location of indicator and devices, accessibility, legibility),
- driver's seat (pressure distribution, comfort angles, range of adjustment in vertical and horizontally plane),
- work area (cabin size, heating and cooling system),
- visibility form the driver's seat.

The preservation of the driver's optimal psychophysical state requires assuring comfort for the driver, by individually selecting elements of the vehicle's construction. In Poland, ergonomic coefficients of the vehicles used by professional drivers come from law and normalization establishments enclosed in norms PN-90/S-47013.

4. THE POSSIBILITIES OF REAL TIME DRIVER'S WORK CONDITION ASSESSMENT

The state of the art and available research tools allow proposing varied methods for real time analysis of the driver's behavior and reactions. The proposed methods can be divided into two main groups:

1) driving style analysis,
2) biomedical indicators of driver's psychophysical fitness analysis.

The first methods base on continuous registration of driving parameters. The registration can be done using instruments that record speed, time, acceleration and vehicle driving direction. Owing to accessibility and generality of such devices, it is important to pay attention on the tachograph. The analysis of the tachograph's recordings described in [7,10], allows determining dangerous states, which result from the driving characteristic. The authors of the papers made an effort to analyze the scanned tachograph's discs used in analog devices. The recordings from the analog devices, owing to a wide statistical range, are a good material to determine the algorithm for dangerous state assessment. The currently implemented digital devices allow analyzing numerical data in real time. Below an example of data registered by digital tachograph is presented.

Kod Kierowcy	Data Start	Start	V(Km/h)	v(m/s)	Odległość(m)	Suma Drogi	Przyspieszenie/Opóźnienie (m/s^2)
Prenom	2006-02-10	09:51:58	75	20,83333	20,83333	21643,74872	0
Prenom	2006-02-10	09:51:59	75	20,83333	20,83333	21664,58205	0
Prenom	2006-02-10	09:52:00	76	21,11111	20,97222	21685,55427	0,27778
Prenom	2006-02-10	09:52:01	75	20,83333	20,97222	21706,52649	-0,27778
Prenom	2006-02-10	09:52:02	75	20,83333	20,83333	21727,35982	0
Prenom	2006-02-10	09:52:03	76	21,11111	20,97222	21748,33204	0,27778
Prenom	2006-02-10	09:52:04	75	20,83333	20,97222	21769,30426	-0,27778
Prenom	2006-02-10	09:52:05	75	20,83333	20,83333	21790,13759	0
Prenom	2006-02-10	09:52:06	75	20,83333	20,83333	21810,97092	0
Prenom	2006-02-10	09:52:07	75	20,83333	20,83333	21831,80425	0
Prenom	2006-02-10	09:52:08	76	21,11111	20,97222	21852,77647	0,27778
Prenom	2006-02-10	09:52:09	75	20,83333	20,97222	21873,74869	-0,27778
Prenom	2006-02-10	09:52:10	75	20,83333	20,83333	21894,58202	0
Prenom	2006-02-10	09:52:11	75	20,83333	20,83333	21915,41535	0
Prenom	2006-02-10	09:52:12	75	20,83333	20,83333	21936,24868	0
Prenom	2006-02-10	09:52:13	75	20,83333	20,83333	21957,08201	0
Prenom	2006-02-10	09:52:14	75	20,83333	20,83333	21977,91534	0
Prenom	2006-02-10	09:52:15	76	21,11111	20,97222	21998,88756	0,27778
Prenom	2006-02-10	09:52:16	75	20,83333	20,97222	22019,85978	-0,27778
Prenom	2006-02-10	09:52:17	75	20,83333	20,83333	22040,69311	0
Prenom	2006-02-10	09:52:18	76	21,11111	20,97222	22061,66533	0,27778
Prenom	2006-02-10	09:52:19	75	20,83333	20,97222	22082,63755	-0,27778
Prenom	2006-02-10	09:52:20	75	20,83333	20,83333	22103,47088	0
Prenom	2006-02-10	09:52:21	75	20,83333	20,83333	22124,30421	0

Fig. 2. Data registered by a digital tachograph (Source: Drabpol)
Rys. 2. Dane zarejestrowane za pomocą tachografu cyfrowego (Źródło: Drabpol)

As it can be seen on Fig 2, the details of speed are recorded every second, so it's a reliable information about the current situation on the road. It is worth noticing, that the speed is in particular time periods recorded only in the memory of the device, which stores data from the previous 24 hours. For this reason creating an algorithm for dangerous states' assessment using analog tachographs' discs was proposed.

The second proposed method of analyzing biomedical indicators base on calculating physiological indicators of limitations of the driver's psychophysical fitness, connected with the fatigue or aggression on the road. In case of this method the registration devices can process measured data that came from selected measurement points:

- The driver's facial skeleton image - the image is registered using one or more digital cameras, which are placed inside the vehicle. A tool created by a German institute: Fraunhofer-Institut für Integrierte Schaltungen IIS is an example of software detecting the face and eye area. On Fig. 3 an analysis of the real image sequence, made within the confines of our research is shown.

Fig. 3. An example of face and eye region detection using an application from the institute: Fraunhofer -Institut für Integrierte Schaltungen

Rys. 3. Przykład detekcji obszaru twarzy i oczy za pomocą oprogramowania instytutu: Fraunhofer -Institut für Integrierte Schaltungen

The analysis concerns: measure of eyeball movement, measure of number of blinking, measure of time of single blink, head movement tracing or fixed point observation i.e. mirrors, widescreen. Acquired data can be used to determine the percentage of time during which the eye is closed (PERCLOS), which, according to results of previous studies [20], is one of the most reliable factors of the driver's fatigue assessment. What is more, observing the head's movements, especially penchant for head bobbing, dropping or rolling, could provide information about the driver's drowsiness.

- The EKG measure of the heart - this method consists in assessing the work of the heart-vascular system by a constant registration by an electrocardiogram. To do this, "holter" monitoring or dynamic registration the heart's work needs to be applied. Changes of the driver's pulse and disorders of cardiovascular system could inform about driving monotony.
- Galvanic skin response – testing the electro-thermal activity of the human body (the change of the skin conductivity). Skin electric conductivity is connected with the activity of the sweat glands and the changes that happen in epidermis. The change of the skin's resistance can be an indicator of changing of the driver's psychophysical state.
- Plethysmographic measurement – a method of measuring the blood's wave pulse that flows or is present in a particular organ. To do this a measurement instrument that registers the change of light beam refracted by blood stream is needed.
- EEG measurement - a method of measuring the brain waves activity by an electroencephalograph. The examination needs the use of measurement sensors (electrodes) on the driver's skull skin. The electroencephalograph measures changes of the electrical potential on the skin surface, which are produced as a result of the cortex's neurons' activity. Spectral

analysis of EEG, especially analysis of theta and alpha waves, makes it possible to detect dangerous states of limited vigilance and lapses of attention.

5. SUMMARY

The previous methodology of applied psychological and physiological examinations, which purpose is to determine the usefulness of a person to be a professional driver, has a general context. It does not take into consideration specific factors and conditions, to which a driver is subjected during everyday work. Carried out examination standards are some kind of an average, giving a reasonable information only about the predispositions of a person to drive a vehicle. Assuming, that the currently worked out methods for the driver's state assessment have a preliminary character, it seems purposeful to create control tools, analyzing the driver's actions and reactions in the real time of driving the vehicle. The implementation of the described dynamic analysis methods in research purposes allows choosing the most reliable and representative coefficients of the driver's psychophysical state and create dependable control-measure tools.

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