

SOME NEURO-PHYSIOLOGICAL ASPECTS OF TRAFFIC SAFETY

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The problem of expert estimation of the state of cognitive functions of drivers of elderly and senile age is examined in the article. Exactly in this age probability of development of cognitive disorders rises up to dementia. The age-dependent changes of cognitive functions affect the sphere of memory, psychomotor, visible-spatial, verbally-logical capabilities, and increase of time of reaction. It is suggested to include the cognitive evoked potentials (CEP) in the standard of expert estimation of the state of drivers in age from 60 years. For the ground of application of CEP the latency of P300 and time of reaction of driver in a transport stream are confronted. Researches of micro-model of motor transport stream are for what conducted and information of timing reaction of driver is got. On the basis of comparison of age-dependent norms of neuro-physiological indexes and findings of time of reaction of driver, criteria are offered for a selection on additional deep research of cognitive functions of drivers of indicated.

Keywords: the cognitive evoked potential, expert estimation of the state of drivers, the traffic safety, micro-model of the motor transport stream, the time of the reaction of the driver, quick spline-transformation

1. Introduction

Growth of amount of cars and increase of traverse speed results in the substantial enlargement of intensity of motion on roads. Therefore 'pondering' is a problem of providing of safety of motion in the mixed transport stream. From data of World Health Organization, annually as a result of road traffic accident perishes about 1,2 million and over 50 million persons are got by wounds. In accordance with the system of William Haddon a travelling traumatism is the result of violation of co-operation of man, vehicle and environment [1]. The problem of reliability of driver is difficult owing to the multiple-factor, because includes the technical questions of construction roads and cars, information and physics theories, psychology and physiology of man. The important index of work of driver is speed of his reaction.

2. Decision of Problem

The normal psycho-physiological state of driver plays an important role in the prophylaxis of travelling traumatism. Variety of factors, influencing on the state of driver and aggregate of road traffic situations determines reliability of driver as probabilistic index, but not strictly determinate. The basic psycho-physiological functions of man, providing his reliability as driver, are certain by Nebylicin V.D. [2]. They can be divided by three groups: quality of facilities of information, qualification and individual qualities. The ways of increase of reliability of work of driver lie in the removal of two terms – monotony and informative overload. By basic factors, which cause the informative overload of driver, are intensity of a transport stream, the rate of movement of car and alignment of road. Speed of reaction of driver is included in the list of basic indexes of his work. The informative model of W.Hick reflects connection between time of reaction of driver and informative capacity of signal [3].

Among the categories of drivers of different ages it is necessary to select the category of drivers of elderly age. The different vascular, neuro-degenerative and metabolic damages of cerebrum in elderly and senile age result in cognitive disorders up to dementia. The age-dependent changes of cognitive functions

affect the sphere of memory, psychomotor, visual-spatial, verbally-logical capabilities, increase of time of reaction and other. To the cognitive functions behave: gnosis is perception of information, ability to recognize information, acting from sense-organs, and to connect the elementary sensory feelings in integral appearances; memory is ability to imprint, save and repeatedly reproduce obtained information; an intellect is a capacity for the analysis of information, exposure of likenesses and distinctions, general and private, main and second-rate, capacity for abstracting, decision of tasks, construction of logical deductions; speech is ability to understand the turned speech and utter the ideas; praxis is ability to acquire, save and utilize various motor skills, which the learned by heart and automated sequences of motions are under laid; attention is ability to support the optimum for intellection level of psychical activity. Prevalence of dementia in a sea and yellow leaf varies from 5 to 30% depending on the probed age-dependent group and in-use diagnostic criteria. Cognitive disorders, which are beyond an age-dependent norm, but does not arrive at expressed dementia, it is accepted to name the term of «Mild cognitive impairment» (MCI) marked for 16,8% elderly and old people. From epidemiology data, 10-15% cases of MCI during one year are transformed in dementia, and for 4 years of supervision dementia develops for 55-70% patients with the syndrome of MCI. [4,5]. Early diagnostics of these states prevents appearance on the roads of inadequately reactive drivers and diminishes a traffic traumatism. For screening of cognitive violations different test scales are usually used, in particular MMSE. However among the new methods of neurophysiology the cognitive evoked potentials (CEP) of P300 allow during of short duration time objectively to estimate the integrative function of cerebrum and expose cognitive violations on the early stages. Comparison testifies with the results of neuro-physiological research, that this index corresponds most reliably the indexes of attention. At pathology of brainstem-subcortical structures time of reaction is increased, that results in the slowness of thinking and violation of normal dependence between force of stimulus and degree of activating of cortex, accordingly a weak stimulus can cause the meaningful activating of cortex, that clinically shows up impossibility long time to support the begun activity, enhance-able distractibility [4,5]. Thus, research of the cognitive evoked potentials allows getting electro-physiological confirmation of presence for the patient of impaired cognitive functions. Essence of method consists in the neuro-physiological analysis of endogenous events, what be going on in to the brain and related to identification of stimulus, his differentiation, bearing in a mind. During research a patient assigned on identification information more frequent than auditory modality – the series of different stimuli, in which in general mass of unmeaning stimuli there are rare stimuli meaningful, are given, nascent pseudo-randomly (on each the 5 unmeaning appear 1-2 meaningful stimulus). Thus in reply to appearance of certain information (meaningful stimulus) a patient must accomplish a certain action (for example, to push the button). Separate averaging is automatically conducted on the produced unmeaning and meaningful stimuli. An answer for a meaningful stimulus differs from an answer for unmeaning appearance of late components of the auditory evoked potentials, namely late positive wave which reflects the cognitive constituent of activity. It arises up on the average through 300 ms after sensory stimulation (component of P300). The presence of cognitive disorders is accompanied the increase of latent period of component of P300. The latency and amplitude of complex P300 have the expressly outlined scopes of norm for all of age-dependent groups. In a norm latentness and at P300 for 60-70 years 361 ± 22 ms makes, for 70-80 years according to a 388 ± 20 ms. If the latency of preceding negative peak of N2 specifies in a time of identification and differentiation of stimulus, the latency of P300 testifies to the decision-making and memorizing [6]. For activity of driver close connection of perception of situation is characteristic with its comprehension, execution made a decision, action of extreme factors, emotionally-volitional tension, variety of processes of decoding, and, in our view, most important is a limit of time. Exactly this dwell for a driver with cognitive disorders can play a fatal role in the conditions of dynamic changing travelling situation of modern megapolis.

For the decision of problem of reliability, as it applies to road traffic, it is necessary to set connection between the psycho-physiological indexes of work of driver and travelling terms. As these information can be got only empiric a way, the necessity of lead through of experimental researches is obvious. The purpose of our work was by comparison of indexes of latency of complex P300 CEP and time of reaction of driver at motion in a transport stream to ground expedience of application of CEP in the expert estimation of the state of drivers of elderly and senile age. Time of reaction is determined from position of physiology complication and amount of links on the way of passing of nervous impulse, and also by the degree of excitability of these ways. We put a task, utilizing the mathematical analysis of the micro-model of a transport stream – movement after the leader, to find out time of reaction of driver in the different conditions of the movement of motor transport stream.

As a result of experimental researches there were the got records of motion of transport vehicles in the different conditions of the movement («slow traffic», « traffic jam», free motion) of a transport stream in the modern real terms. The records of data from GPS-receiver are got by an atomic clock. We will make an example of records of fragments of motion of two «coupled» transport vehicles in a high-density transport stream («slow traffic») (Figure 1), examples of calculation of their speeds (Figures 2;3) and time

of reaction of driver (Figure 4) classic and offered methods [7,8]. In accordance with the formula of the following model by a leader:

$$\frac{dv_n}{dt} = \frac{1}{t_p} (v_{n+1} - v_n), \quad (1)$$

where time of reaction of driver: $t_p = \frac{(v_{n+1} - v_n)}{\frac{dv_n}{dt}}$, $\frac{dv_n}{dt}$ – acceleration of back car; v_n и v_{n+1} – speeds of back and front cars.

At the calculation of parameters of micro-model of motor transport stream – the movement after the leader in a high-density stream is ascertained that mean time of reaction of driver, calculated a classic method, is 1,1 s.[9, 10] Standard deviation (SD) of time of reaction of driver is 3,35 s. Mean time of reaction of driver, calculated by the offered method, is 0,64 s. SD of time of reaction of driver are 1,65 s. The average index of time of reaction of driver in the different regimes of the movement on all of way of experimental researches made 0,57 sec., an experiment lasted 2300 sec.

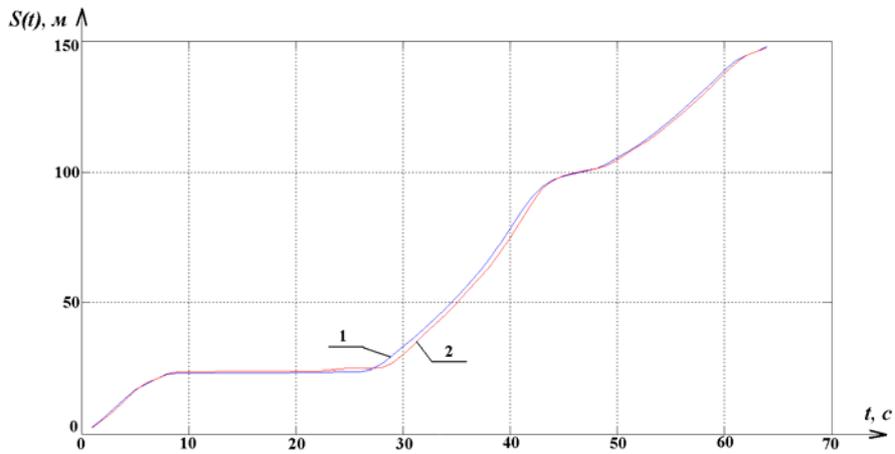


Figure 1. A fragment of motion of two cars is in a high-density transport stream («slow traffic »).
1 – motion of leading car; 2 – motion of car which follows after a leader

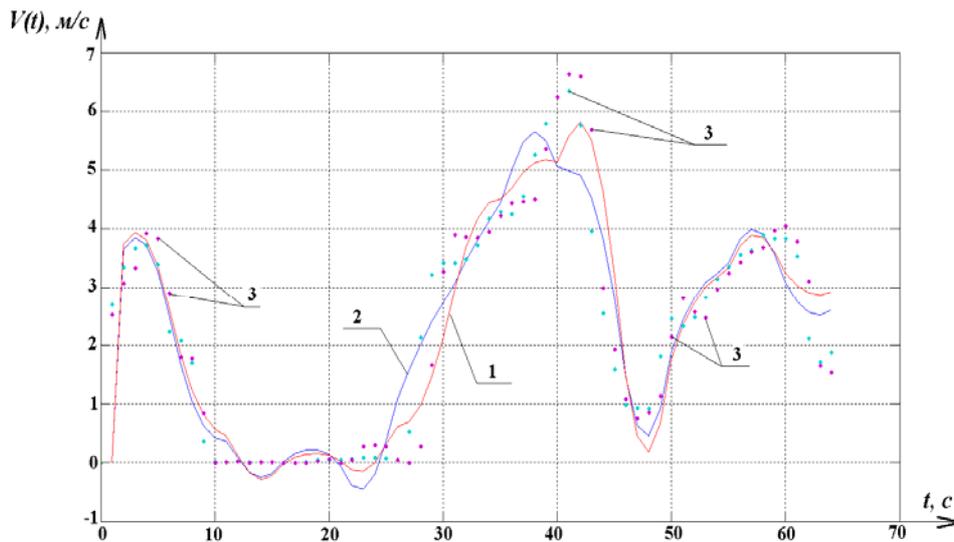


Figure 2. Calculation of speeds by a classic method, where 1 is speed of leading car; 2 is speed of car, which follows after a leader in a transport stream; 3 are speeds, expected as the divided difference

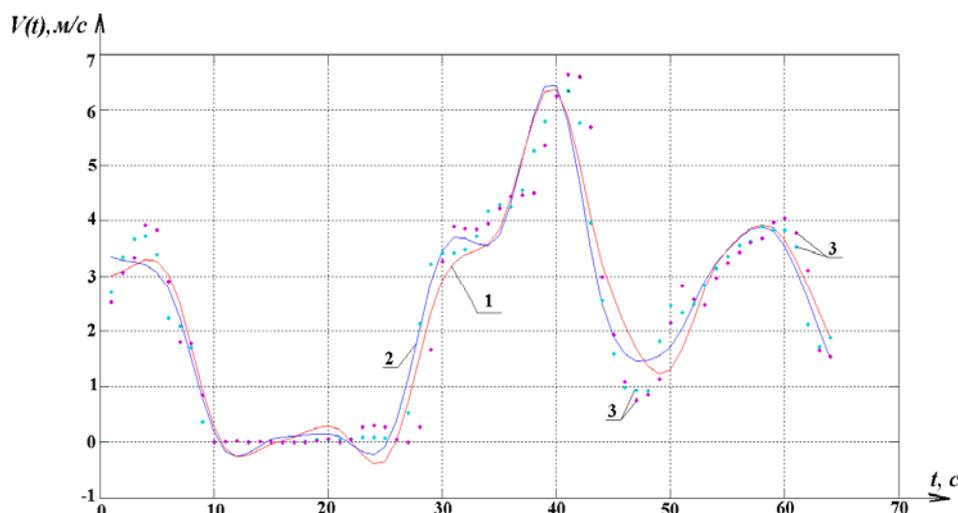


Figure 3. Calculation of speeds by the offered method, where 1 is speed of leading car; 2 is speed of car, which follows after a leader in a transport stream; 3 are speeds, expected as the divided difference

Even by sight the «smooth» structure of the expected speeds is visible, that answers the real state.

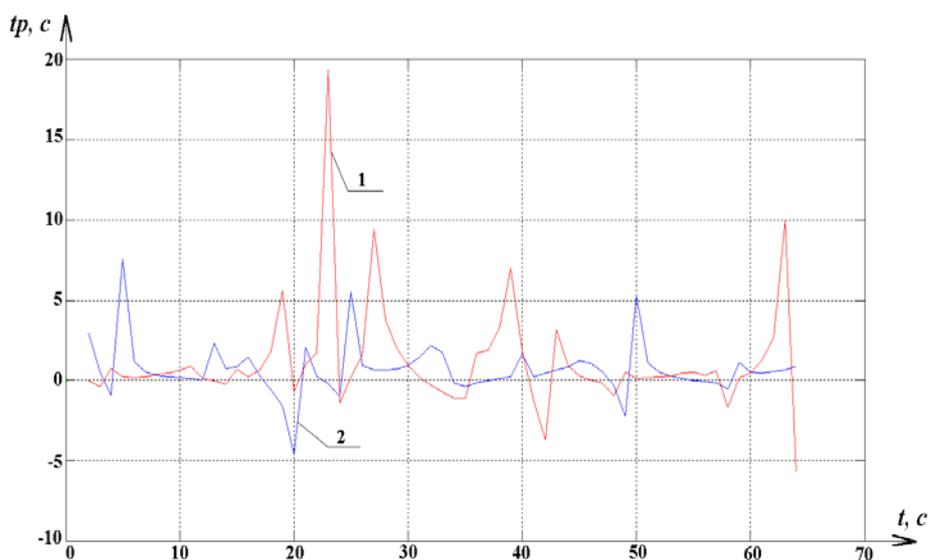


Figure 4. Calculation of time of reaction of driver, where 1 – time of reaction, expected a classic method; 2 – time of reaction of driver, expected the offered method

Speed and time of reaction of driver the offered method settle accounts more precisely, than classic.[11,12] On it indicates less than SD of parameters which are calculated.[13, 14] At comparison of quality of the got results of calculation in the different regimes of the movement of cars, on the example of time of reaction of driver, by the offered and classic method, it is set that the middle gain in exactness of the offered method as compared to classic was 57%. [15]

As a result of the conducted researches an average index of time of reaction of driver in the different regimes of the movement of motor transport stream was 0,57s or 570ms. Thus, taking into account the maximally possible scopes of norm for P300 – 408ms and total time of central motor conduction and conduction on motor peripheral fibres about 40ms, for realization stand a reaction on a simple enough and of the same type irritation and simple motor reaction needs for people from 60 to 80 years approximately 450 ms. And because, for example, the reaction of driver on the blazing up signal of braking of going ahead car behaves to the difficult motor reactions and accordingly requires greater time and remaining 120 ms often are insufficient for the adequate difficult reaction of people of elderly or senile age on the folded travelling situation in the conditions of megapolis. And ill-timed or inexact reactions quite often result road traffic accident. Accordingly time of motor reactions is increased at the

disease state of driver, and especially at presence of cognitive disorders. Most exactly and it is adequate to estimate and express in a digital kind the degree of violation of speed of reaction allows research of CEP, just determination of latency of P300. Early cognitive violations, related to the foregoing damages of brain, and also with the protracted abuse of alcohol, some drugs, and also with the syndrome of sleepy apnoea and narcolepsy, reflected in the change of parameters of P300. Often at expert examination of neurologist these cognitive disorders remain not recognized and a driver gets admitting to the management a vehicle.

3. Conclusions

Absence of P300 or increase of latency on more than 100-120ms from an age-dependent norm are, in our view, by meaningful indexes for a selection on additional deep research of cognitive functions in future for the decision of question about the possible admitting to driving of car.

The inclusion of CEP in the standard of expert estimation of the state of drivers in age from 60 years and more senior will allow reducing a traffic traumatism. Modern perfection of practice of planning of roads and organization of road traffic requires further researches, related to the conduct of driver, his reactions and possibilities.

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