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The human reaction speed study under the action of different stressors

Introduction

The attention and response time have an influence on the successful orientation of a person in the world at the interaction with other objects, which is especially important for the study of problems in the field of occupational safety. The installation and directionality of human attention determine his consciousness and selectivity. Focused attention and ability of quick response to external influences are necessary criteria in the work of not only many specialty representatives (military, pilots, drivers, operators), athletes (all types of wrestling, team games) but also is very important in everyday life (self-defense, reactions to life-threatening events, etc.). The reaction time shows how well the nervous system is.

As already known, the time of information processing is the basic human cognitive ability. From the beginning of the stimulus to the moment of respond, it always takes a certain time, after that the muscle mechanisms of the corresponding action include, and their time depends on the body movements time. The reaction time delay is called the latent time. It is determined by the time of metabolism and is a feature of each individual organism. The latent reaction time is not training because it is impossible to increase the nerve impulses transmission time. Muscle mechanisms on the contrary can be trained.

The purpose of this work was to investigate human response during different types of influence (light, sound, and combined) and to process the obtained results by the different statistic methods.

Nervous system, reflexes, reactions

The nervous system is a complex network of structures that permeates the whole body and provides precisely the regulation of its activities, due to its ability to respond the internal and external influences. The nervous system main functions

are processing, storage, obtaining information from the environment and from the inside, the organs and body systems activities coordination [1].

Nervous regulation is the body's functions regulation by the reflexes that nervous system performed.

I.M. Sechenov one of the first made assumption that the brain higher parts have a reflex nature and extended the term "reflex" to any, including the higher nervous activity (HNA). Doing that, he noted [2]:

– every activity of body is ultimately reduced to movement,
– all movements of body are reflexes.

Reaction is the body response to the external or internal irritations. There are psychological response, physiological response and immunological response [3].

The response time of a person to the stimulus (latent time) is the time interval from the signal start to the appropriate body response. It is considered, that the latent time can be divided into 3 phases:

– the time passage of nerve impulses from the receptor to the cerebral cortex,
– time required for the nerve impulses processing and the organization corresponding response in the central nervous system,
– time in response to the action of the body.

Reaction time is often dependent on stimulus modality, in other words, on the type of signal-activator, intensity of the stimulus, training, readiness for the signal perception, age and gender, complexity of the reaction (simple or selective). Changing within wide limits, the reaction time in the best cases is at least 0.15 sec. (recognition of visual images at least 0.4 sec.) [4].

The basis of any reflex or reaction is a reflex arc or a reflex path. The reflex arc (RA) is an undergoing path of appropriate reaction, that is, nerve signals.

The reflex arc of the somatic (motor) reflex consists the following basic links:

1. Receptor that perceives irritation.
2. Afferent neurons (ascending or sensitive) nerve fiber.
3. Nerve center in the central nervous system.
4. Efferent neurons (motor) nerve fiber.
5. Executive organ – effector.

A receptor is a structure that perceives information. Receptors perceive the energy of the stimulus and convert it into nerve impulse energy.

Excitation from receptors is transmitted to the reflex nerve center, then acts as an effector – an executive organ that changes its activity, focusing on the stimulus. The effector organs are the glands or muscles. [5].

The human body lives and acts in the external environment. The time and correctness of the body's response to various events ensures its survival. The nervous system regulates the activity of all systems of the human body and responds to changing conditions of the internal and external environment.

The nervous system consists the central system with the brain and spinal cord, and the peripheral system with the nerves located outside the central nervous system (CNS).

The nervous system consists a central CNS – the brain and spinal cord, and peripheral (PNS) – the nerves located outside of the central nervous system.

The signal transmission from the CNS to and from the organs is carried out through the nerve tissue through the nerves.

Nerves are the accumulation of long shoots nerve cells. Neurons are the main cells of a nervous tissue, consisting a body and shoots. The nervous system activity is based on reflexes. It is the body's response to irritation that occurs with the participation of the nervous system. Reflexes are performed through reflex arcs, the pathways through which a nerve impulse passes during reflexes.

Factors affecting reaction time

Why is reaction time important and how does it affect our lives? A good response time allows us to be flexible and effective responding to different stimuli and situations. When talking, while driving or playing sports, etc. Adequate reaction time gives us benefits; however, we need to process information correctly: if we are asked questions during an interview, we are expected to respond quickly and correctly. Another example: when we are faced with situations driving a car or playing in the gym, it happens in a similar way – it is not enough to act fast, not to act well, it is necessary to do it at the same time. Fortunately, response time can be trained and improved.

Examples of reaction time (response):

1. If you are driving and you suddenly notice the pedestrian near the crosswalk, the time that it takes from when you notice the pedestrian, make the decision to slow down and perform this action is a reaction time. This cognitive ability can save us from many accidents.
2. In a boxing match or football game, it is extremely important to detect the opponents move on time and know what they're going to do in order to react as quickly and accurately as possible. Good reaction time is the key to outcome.
3. You are indoors and you suddenly notice a fire. In this case, the reaction time is the time you need immediately after the fire detection to find the nearest fire extinguisher.
4. When a guard detects suspicious activity, the time it takes to respond can be crucial for successful intervention in the situation. If he or she finds, for example, a theft, response time would be the time between when he or she finds the robbery and start taking action to prevent it.

Reaction time or response time is the amount of time that takes places between when we perceive something to when we respond to it. In other words, it is the ability to detect, process and respond appropriately to a stimulus.

Reaction time depends on many factors:

1. Perception: surely opportunity to see, hear or feel is an essential stimulus to have a good reaction time. For example, in athletics, when a referee gives a signal of a race start, the sound is received by the athletes' ears (they perceive the stimulus).
2. Processing: In order to have good reaction time, it is necessary to concentrate and understand the information well. Following the example above, the athletes, after

hearing the start signal, will be able to distinguish the sound from other background noises and realize that it is time to start running (process the stimulus).
3. Response: motor agility is necessary to respond promptly to the stimulus. When the athletes received and correctly processed the signal, they start running (respond to the stimulus).

If any of these processes is changed, reaction time (response) will be adversely affected. In other words, an athlete with a low reaction time will be at a disadvantage compared to their opponents. In addition, reaction time necessarily includes a motor component as opposed to information processing speed. That's why a good reaction time is equated with having good reflexes.

In this example, the process chains (perceive, process, and respond) is performed in milliseconds, but reaction time can vary depending on other factors:
1. Complexity of the stimulus: the more complex the stimulus, the more information has to be processed, and therefore the more time it will take.
2. Simplicity, preparation and expectations: if we need to respond to a familiar stimulus that we have already responded before, the time reaction will be greatly lower. The less new information we need to process, the faster our response will be. If (as in the example with the athletics) you expect the stimulus (athletes know about the signal), reaction time will be even lower.
3. State of the organism: factors such as fatigue, attention (sleepiness), high fever, old age, or even overeating or taking substances such as alcohol and drugs can negatively affect the reaction time. That factors can have a negative impact on the detection of the stimulus, its processing and responding to it.
4. Stimulated sensory modality: the response time will be better when the stimulus that starts response is auditory rather than visual because such stimuli require less processing time. Each sensory modality implies a different response time.

In addition to these factors, the type of stimulus that we process will also affects reaction time:
1. Simple: one single response to one stimulus. For example, when we press the space bar when a new word appears.
2. Alternative: different responses to different stimuli. For example, on the keyboard, we press the left arrow key if the word appears in English, and press the right arrow key if the word is Ukrainian.
3. Selection: at the presence of various stimuli we only have to respond to one. For example, press the space bar when appears Ukrainian word. If an English word appears, do not touch the keys.

Time reaction tests

Time reaction is taken into account in the development and design of control panels, information display systems, conveyor lines, operator workplaces. Time reaction is widely used in professional selection; it is a criterion by which can be determined a person's suitability for such professions as dispatcher, operator, driver,

etc. Time reaction is also taken into account in sports and management activities, in clinical practice to determine the state of the nervous system.

The reaction time is present in most of our everyday work. Our reaction time (respond) depends on our ability to interact with the environment and respond to unforeseen changes. Thus, reaction time evaluation is important and can be useful in different life areas: in education (can help us to know if a person has problems with perception, information processing or motor skills and related learning difficulties), in medicine (to identify patients with disorders related to perception, information processing or motor skills), in profession (helps identify better prepared employees for the types of work related to act quickly in certain circumstances).

Various cognitive functions, including reaction time, can be effectively and reliably evaluated using comprehensive neuropsychological testing. Typically, there are used classic tests: NEPSY, Test of Variables of Attention (TOVA), Continuous Performance Test (CPT), Test of Memory Malingering (TOMM), and Hooper Visual Organization Test (VOT). In addition to reaction time, working memory, visual scanning, visual-motor coordination, inhibition, name memory, visual perception, contextual memory, recognition, focused attention and spatial perception can also be measured.

Examples of tests for time reaction determining:

1. Test Investigation REST-COM: various images of objects appear briefly on the screen. Then, as soon as possible, it is necessary to select the word corresponding to the presented images.
2. Decoding Test VIPER-NAM: the screen briefly displays images of objects that then disappear. After that, four letters appear, and only one of them corresponds to the first letter of the object name, it is necessary to choose this letter correctly. The task should be completed as soon as possible.
3. Recognition Test WOM-REST: three objects appear on the screen. First, it is necessary to remember the order in which they appear as soon as possible. Then three sets of four different objects will be presented there will be four series of three objects that are different from those previously submitted. It is necessary to restore the original sequence.
4. Resolution Test REST-SPER: several moving stimuli appear on the screen. The task is quickly select the right one, avoiding clicking on others.
5. Speed Test REST-HECOOR: a blue square appears on the screen. It is necessary to click on it as soon as possible while remaining inside the square. The more times a button is pressed in the allotted time, the better results will be.
6. Processing Test REST-INH: two blocks with different numbers and figures appears on the screen. First it is necessary to respond on the size of figure and specify the highest, then select the block with the largest number among represented [9, 12].

Reaction time in theoretical and applied researches

Reaction time measuring in the experimental study of various mental problems has a long history and tradition. Chronometry is one of the first classical psycho-

physiological methods, and, in the opinion of XIX century Dutch physiologist Frans Donders, the founder of this method, one of the most important in determining the connection between the specific features of each feeling, imagination, volitional act and certain features of brain activity [7].

F. Donders first developed a schematic diagram of the experiment which allows to determine the temporal parameters of mental processes. He suggested that complicating of experimental tasks would lead to the addition of new stages, and consequently, to reaction time increasing. This increase value of the reaction time corresponds to the additional stages' duration. According to the classical concept, the total time of any motor reaction consists several components:

– incoming sensory information,
– stimulus recognition (categorization),
– choice response,
– organization of motor response.

In the last one and a half centuries studies of the total reaction time and its components have been carried out in thousands of different studies [7, 8]. These studies can be divided into several directions, the reaction time in which is:

– as a dependent variable on a number of external factors (stimulus intensity, sensory modality and sensory signal quality, inter-pulse interval, etc.),
– as a unit of analysis of individual differences (by age, gender, nervous system properties, professional skills, etc.) or used to evaluate functional status,
– as a tool for analyzing the mechanisms of cognitive processes in cognitive psychology.

Now, most researchers are interested in studying not only the average reaction time, but also in analyzing the distribution of results [10]. It is established that multiple measurement of the reaction time of any individual in unchanged experimental conditions reveals significant fluctuations of this parameter, individual values of the reaction time may differ from the average obtained in the same individual in the same experiment 1.5-2 times [7, 8]. However, the distribution form of the reaction time results, registered at different times, is relatively constant for each individual tested under comparable experimental conditions [11].

Personal computers have greatly simplified chronometric studies, automate the testing process, and at the same time expanded the capabilities of the experimenter.

Each method typically consists several series recording different types of reactions, the main ones are:

1. Simple sensorimotor reaction. The examinee should respond as soon as possible to any stimulus. The time of this reaction consists the receptors excitation time, excitation transfer to the relevant sections of the cerebral cortex, start time of the motor program and actual reaction motor component.
2. Differentiated simple choice reaction. The examinee responds to stimuli of a certain type and ignores all others. The time of this reaction increases by the additional information processing stage appearance. This central delay is referred to as the time

of cognitive processes. This stage is mainly related to the cognition processes, the stimulus attribution to a particular group, category.

3. Differentiated complex choice reaction. The examinee responds to each type of stimulus of a particular motor response. The time of this reaction increases more mainly by increasing the deciding duration how to respond to a stimulus [3].

The tasks in the methods are selected in such a way that it is possible to determine as effectively as possible the influence of various factors on the total reaction time and its components. As an interpretation scheme of the obtained results has used F. Donders' representation of the composition component of reaction time and S. Sternberg's paradigm, according to which each factor influences the duration of only one, "its" stage of the cognitive problem process solving and in no way can affect the duration of the others stages [8].

Methods and results of reaction time studies

Since the purpose of this work is to conduct a latent time study of the person simple sensorimotor response to the irritation and results processing. It was decided to use only the exteroceptors, namely, a visual analyzer and a human hearing aid. Those receptors were chosen because it seems most convenient to influence them from the outside.

A simple reaction in psychology is called a reaction that is carried out in the presentation conditions of one pre-known signal and receiving one specific answer.

Before starting the experiments, a number of persons (examinee) who participated in the experiments were identified. And a survey, which indicates gender, age, education profile, health status, ability to drive (driver license) and regular sport activities was conducted. Ten students from Lviv Polytechnic National University participated in the survey. Of the examinees, those who on a regular basis take sports or part in activities that require the reaction speed training (car drivers) 2 people. The gender division is as follows: 5 males and 5 females, 21-22 years old. The health status of all examinees is satisfactory and they all are one group students (transport technologies). For better results of the research carrying out time is chosen one: 12.00-14.00.

The program «Are your reactions?» was used for time measurement of the simple reaction [13].

Each examinee sat comfortably in a chair and watched the monitor of a personal computer. In front of the examinee was a picture with a road projection and a green button START in the middle.

The car movement simulation on the road was began after clicking the button "START". The examinee watched the picture closely and waited the appearance white hand on the red circle.

When this warning sign appeared:

 (white hand on a red circle),

the examinee had to press the button in order to stop the countdown time (the time between the appearance of "danger" and clicking on the button).

The reaction time (in milliseconds) was the interval duration between the stimulus appearance (white hand on the red wheel) and the beginning of muscle activity. This test is a model of high-speed characteristics of the activity.

Five series of measurements were performed for each examinee to determine the reaction time under the action of the following stressors:

1. In a calm focused state.
2. With distracting stressors:

2a. Answering simple questions (What is your birth date? What is your parent's name? Where do you live? Etc.).

2б. Answering complex questions (multiplication table).

2в. Talking on a cell phone (all examinees spoke on simple everyday topics).

2г. Writing text on a smartphone (all examinees typed plain (identical) text).

2д. At the peripheral vision (simulation of observation on the navigator, mobile).

For each sample of time values, the arithmetic mean, the absolute and relative errors, and the root mean square deviation were calculated. Graphical dependencies were created according to the average values of each measurement Fig. 1.

The obtained data show that the proposed stressors do impair the reaction time of the person compared to the resting state. However, their effect on the reaction time reducing is not straightforward and requires more detailed studies.

For example, it turned out that the reaction time at the peripheral vision is almost identical to the reaction time at rest (curve 6 and 1).

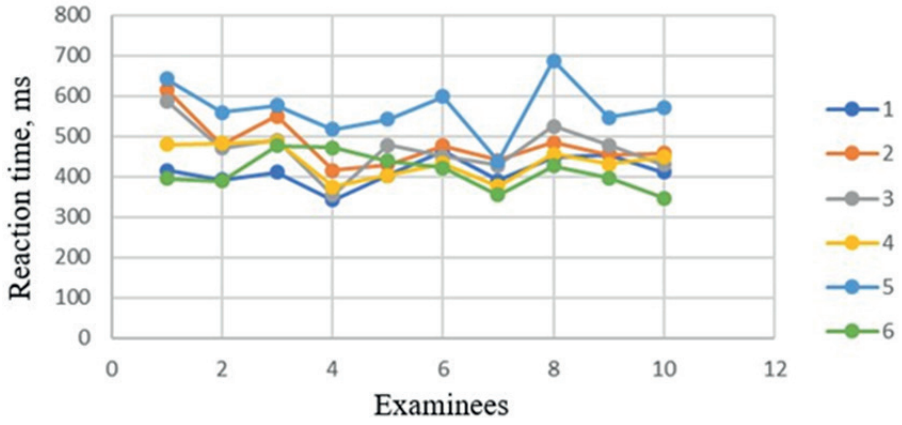

Fig. 1. The dependence of the reaction time on different stressors:
Curve 1– in a calm focused state; Curve 2 – answering simple questions (What is your parent's name? Where do you live? Etc.); Curve 3 – answering complex questions (multiplication table); Curve 4 – talking on a cell phone (all examinees spoke on simple everyday topics); Curve 5 – writing text on a smartphone (all examinees typed plain (identical) text); Curve 6 – at the peripheral vision (simulation of observation on the navigator, mobile)

The conversation on the mobile phone on simple topics also had little effect on this value (curve 4). The examinees distraction to the writing text on a smartphone, by far, had the greatest impact on the reaction time reducing (curve 5).

However, it turned out that those questions that were considered simple at the beginning of the study appeared to be more complex for the examinees than the multiplication table (difficult questions).

Obviously, the multiplication table was repeated by students to automatism in the learning process, both at school and at university, but data such as parents' name and patronymic, their date of birth, place of residence – caused additional mental effort in the examinees, and caused the reaction time to slow down.

Therefore, for further research, the following stressors were selected, the action of which would be more influential and informative:

1. In a calm focused state.
2. With distracting stressors:

2а. Answering simple questions on a cell phone (How are you? What are you doing? Are you going to university tomorrow? are you going home? Etc.).

2б. Answering complex questions on a cell phone (arithmetic: 57-29; 63-27; 72-65; 91-56; 86-93; 76-95).

2в. Browsing social networks (eyes looking at smartphone screen).

According to the study results (average values of each measurement) graphical dependencies were created Fig. 2.

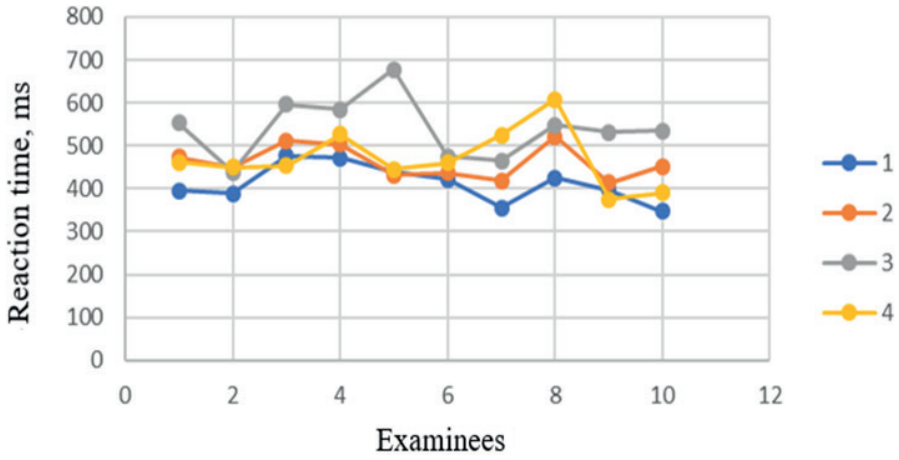

Fig. 2. The dependence of the reaction time on the complicated stressors:
Curve 1– in a calm focused state; Curve 2 – talking on a cell phone (all examinees spoke on simple everyday topics); Curve 3 – talking on a cell phone (complex arithmetic actions); Curve 4 – at the peripheral vision (browsing social networks)

Obviously, a focused conversation on the phone do the greatest worsening in the reaction time (curve 3). The results are worse than the control ones (curve 1) by

30-40%. Also, most of the study group worsened the reaction time in the case of viewing social networks (curve 4).

The root means square deviation graphs (Fig. 3 and Fig. 4) were presented according to the mathematical processing results. The standard deviation (standard error of the sample mean) is an estimate of how far the sample mean is likely to be from the mean, while the standard deviation for the sample is the extent to which individual events within the sample differ from the sample mean.

A similar pattern is observed for the first and second series of experiments. The root means square deviations for the examinees in the calm, concentrated state (curve 1) are much smaller than for different stressors.

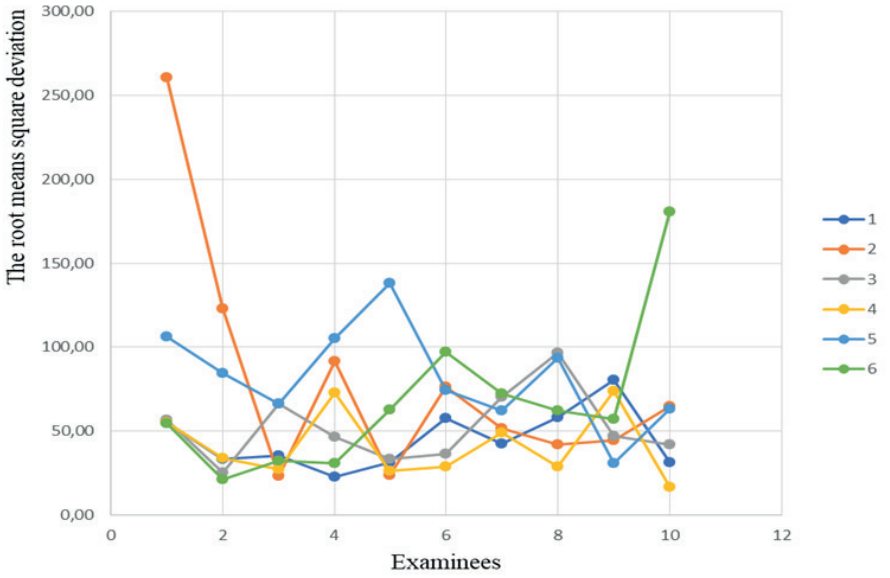

Fig. 3. The root means square deviation, experiment 1

The human reaction time measuring continues to be one of the most promising methods in psychophysiological research, including occupational safety field.

Accurate adherence to the parameters and conditions of each experiment is important in order to obtain the experiment reliable results conducting with the different examinees participation. Therefore, a personal computer is chosen as the assistant to create stimuli: all actions are generated by strictly rules defined and their influence is limited by the area of interaction with the computer.

Therefore, as a research result on the reaction time determination of the person and influence of different stressors on it, we can do a number of conclusions.

The reaction time average for light stimuli is from 350 ms to 700 ms, although according to the literature the lower limit is 150 ms. This is because the reaction time is divided into three phases: the time passage of nerve impulses from the receptor to the cerebral cortex; time required for the nerve impulses processing and the or-

ganization corresponding response in the central nervous system; time in response to the action of the body.

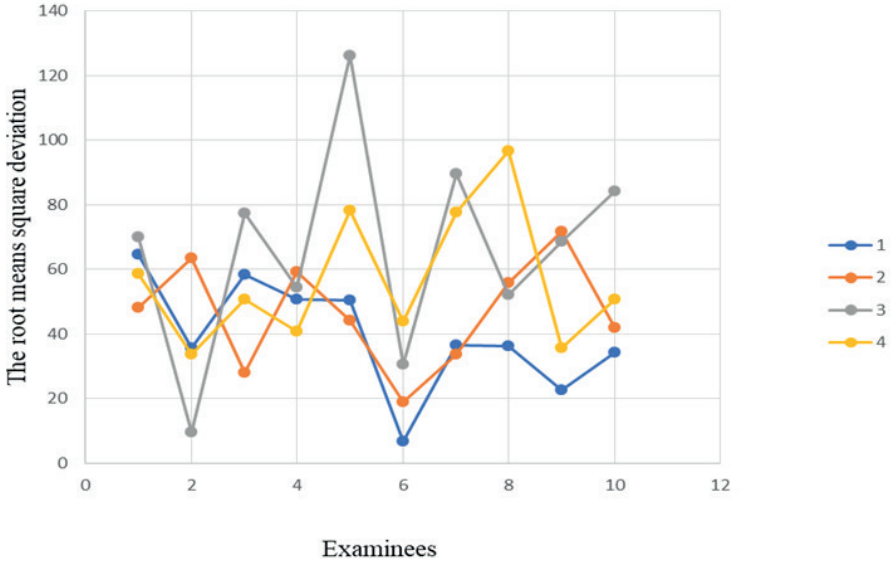

Fig. 4. The root means square deviation, experiment 2

Conclusions

In sports people and who have constant experience in driving, the reaction time to the outside is slightly shorter (examinees 1 and 7). In people who do not take sports and do not have the driving skills – the reaction time is worse. Obviously, reaction time can be improved by exercise.

In all experiments, the men reaction time is shorter than in the same age women (examinees 1, 2, 4, 7, 10).

There was established that any distraction (stressor), conversation, cell phone usage, attention focus on another object, background noise increases the reaction time. Therefore, for example, the driver should not talk on the cell phone while driving.

An important and reliably established fact is that conversation on the phone has the biggest influence on the time reaction deterioration, provided that the person focuses on the conversation topic. Obviously, such a pattern is observed in a conversation not on the phone only. That is, a greater impact on the reaction time has a human focus on any object beyond the one that needs attention (such as the road).

In the future, we plan to continue work on this topic and investigate the reaction time of the distinction (a reaction that occurs when a person is required to respond only one of two or more signals and the response must occur only one of them) and choice (the reaction when two or more signals are presented, but provides each of them responds with some action).

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