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ATTENTION LEVEL INDICATORS

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Abstract: **The area of investigation of the reliability of interactions between the human subject and artificial system, namely of the transportation nature, has to be considered as one of the most important part of the contemporary applied brain science. For all the necessary investigations the fast and reliable determination of the actual attention level is necessary.**

The attention and vigilance can be considered in general as very sophisticated kind of the brain activity.

Though the quantitative estimation of this brain function is provided already for very long time, as far as is known till now no universal and satisfactorily fast, reliable, and accurate method exists.

Moreover, all the known classical approaches to the attention level measurement are of the more or less invasive nature and therefore the measuring procedures affect seriously the actual attention level of the measured subject.

However, there is a hope that by the advanced dealing with measuring of some selected set of physiological indicators, among which the electromagnetic radiation from the human brain dominates, combined with the activity of eye and some human subject effectors (namely with the subject′s hands), the adequate methods for laboratory and also for practical application can be developed.

To be able to provide the necessary analyses, we have to solve some serious problems, like the distant detection of EEG signals above the tested person head, the mining of the common indicator factors from these signals and the analysis of the quasi-periodic and quasi-stationary time-series, which these signals represent.

Some aspects of the solution of these problems will be mentioned in this presentation[1].

Key Words: **Attention, Vigilance, EEG analysis, Systems Reliability, Human – Machine Interface (HMI)**

Introduction

Introducing the problems of reliability of interactions between the driving person and moving car we must before all mention the significance of the losses caused by the respective accidents.

Faults in interaction between the driver and moving car cause daily in the world extremely high number of accidents. Just in the old EU with 15 countries, the total number of road accidents was more than 6 millions in 2002.

Suppose that the average economic loss connected with one road accident was approximately 1700 Euro, not reflecting the part connected with medical care and social aspect of mortal accidents. So we come to the figure of 10 billion Euro per year. For the contemporary 25 member EU such estimate is over 20 billion Euro yearly.

Much worse is that these accidents are in non-negligible part connected with serious injury or death of people, on the side of drivers, passengers and pedestrians. In 2002 EU mortal statistics presented 42000 killed people. Quite reliable financial estimation of the price of medical care is feasible, while the financial estimation of one lost human life is very problematic. Nevertheless if one summarizes all the relevant expenses and the loss of working capacity, education etc., the figure of 1 million € per one lost life is the moderate guess. In 2002 this has represented total of about 42 billion €, which together with above mentioned direct expenses forms the sum of about 52 billion € per year. As concerns the present EU we can speak of more than 100 billion € per year, with increasing trend.

Unfortunately, there was (and still is) no detail statistics to disposal, which could tell us, which part of this number is caused by attention decreases. In some countries some attempts to create such statistics exist, but the used methodologies significantly differ. Therefore one can find the figures from 15 to 50%. In some other countries such statistics does not exit at all.

Nevertheless, if one takes the figure of 20% as the reasonable, more or less conservative estimate, one comes to the number of approximately 8500 mortal accidents from this reason per year[2].

As a result, we have to deal with the amount of 20 billion Euro per year from this reasons.

In the world scale, statistics are even more uncertain, nevertheless very rough estimations reach the value of the order of billion USD per day lost because of the unacceptable decrease of drivers' attention. From the same reason the tremendous number of human beings, of about 470 per day is killed in the World[3].

Main reasons are generally recognized in:

a) Too fast and aggressive driving,
b) Influence of alcohol and other drugs,
c) Bad technical conditions of cars and/or roads,
d) Bad traffic control,
e) Decrease of driver attention in the course of driving,
f) Unsatisfactory level of driver ability and skill,
g) Environmental stresses,
h) Heavy traffic influences.

There is hard necessity to try to minimize all of these negative influences.

In this contribution we concentrate to some part of them namely to those, belonging to the group e) and f).

There exist the following approaches how to improve the present unpleasant situation in these areas:

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[2] (since 2002 in some countries the situation improved due the intensive care in this area – namely in Sweden and England, however in the others it is much worse; therefore as the realistic one can be the estimate that the total numbers from 2002 till now remain almost unchanged)

[3] (per year it is more than 170000 killed people which is about 150% of that number, which killed the Hiroshima atomic explosion)

- Improve our knowledge of driving people attention decreases with respect to the influence of various internal and external stimuli affecting the driver,
- Improve the car cockpit and its control tools with respect to minimization of various negative influences on drivers attention level and driving ability,
- Develop the warning system for in-time information of the driver that he/she is going to be unable to control the car movement safe and reliable,
- Develop the advanced training system, improving the driver resistance against various negative influences on his/her ability of reliable and safe driving.

For all these four approaches two main tools are necessary:

- Satisfactorily fast and specific indicators of actual level of driver attention. Here the dominant role has the analysis of drivers EEG signals.
- Adaptive car simulators with wide screen scenarios in virtual reality.

Here we shall mention some of our results in dealing with attention level indicators and discuss the open problems.

2. Decrease of Attention in the Course of Driving

There is well known and many time proved, that the drivers losses are influenced by the original level of driver's attention, with which they start driving.

In general, this fact causes one of the main differences between the control activity of human being and the control or steering activity of any artificial system:

Any human operator of the system (namely of the transportation nature) must subsequently become tired, his/her attention level falls down and his/her ability of safe and reliable driving diminishes.

Though the speed and forms of such attention decreases change significantly from person to person and also from one case to another with considerably very wide spread, the basic law remains:

An actual attention level of every driver decreases after some time of driving below the acceptable level.

There is no exception in principle.

Let us now discuss the factors, which have the influence on the speed and forms of driver attention decrease procedure.

At first, the <u>individual psychical and physical abilities</u> of the particular person have to be taken into account.

In standard human population there is a great variety in the respect. These abilities differ also with age, sex, race, countryside (region), kind of profession, style of life and, of course, skill of driving. Besides, also the environmental conditions[4] play significant role.

Moreover, also the properties of the particular car and road have to be considered.

Suppose now, that for model situation we have to deal with healthy, young driver who starts driving fresh (after whole night of good sleep) which is in good psychical and physical condition. Suppose further that all the other factors influencing the level of his/her attention in the course of driving can be standardized.

If such driver starts driving at the time t_0 with the attention level L_{A0}, the variation of the actual values of his level of attention $L_A(t)$ varies during the course of driving as schematically shown in Fig. 1.

When driving, the driver is under influence of various stimuli[5] which in general restore the continuous decrease of his/her attention. Of course, such increase of his/her attention is only[6] temporary.

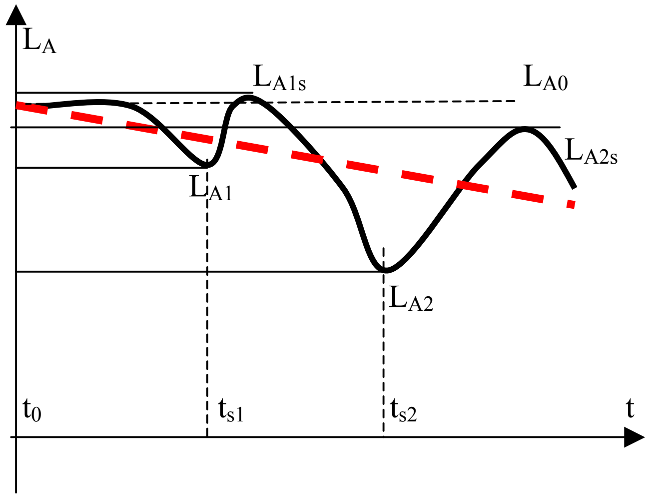

Fig.1: Example of typical dependence of driver attention on time of driving. Here means:
L_{A0} ...attention level at the beginning of driving,
t_{s1}, t_{s2}...time instants, in which the external disturbing stimuli appear,
red / dashed line...average attention level, black line...actual attention level,
L_{A1}...actual attention level at the instant t_{s1} when the stimulus S_1 appeared
L_{A1s}...level of temporary increase of attention after the stimulus S_1
L_{A2}... actual attention level at the instant t_{s2} when the stimulus S_2 appeared
L_{A2s}... level of temporary increase of attention after the stimulus S_2

In Fig.1 it is shown that in the case of the stimulus S_1, the increase of attention level caused by the stimulus was considerably small and lasted briefly, while in the case of the stimulus S_2 this increase was higher and lasted longer.

The frequency of appearance of the stimuli S_i varies and their effect on temporary driver attention restoration is different, however in general the effect of temporary restoration of the attention decreases with time.

Let now turn our attention to the red dashed curve in Fig. 1. This curve, representing the average driver attention level, falls continuously in general, as it is shown schematically in Fig. 2 (at the end of this article).

We can distinguish here 5 typical phases:

- Phase of the full attention (yellow line in Fig. 2),
- Phase of relaxation (green line in Fig. 2), in which the driver is still fully able to control his/her driving

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[4] (season, hour of day, weather, inside and outside temperature, humidity, atmospheric pressure, illumination and more generally electromagnetic radiation level, etc.)

[5] These stimuli have from the driver's point of view either external or internal (body discomfort, emergence of exciting idea…) origin.

[6] Sometimes the temporary increase of attention can lead even to reaching of higher attention, than at the beginning of driving (see the level L_{A1s} in Fig. 1).

activities, but he/she feels to be a little bit tired and he/she slightly relaxes.

- Phase of somnolence (blue line in Fig. 2), in which the driver level of attention is going to fall below the level of reliable and safe driving. Here he/she feels to be really tired, but the reliability of his/her driving is limited, reaction time is prolonged significantly (sometimes 3-5 times) and the probability of his/her non-correct response on external stimuli increases.
- Phase of micro-sleep (red line in Fig.2), in which the driver attention level falls rapidly down till zero or to some very small residual level. In happy cases, this phase lasts considerably shortly (few seconds).
- After that, the driver awakes to some previous phase, in which his/her ability to drive reliable and safe refreshes. This phase (violet line in Fig.2), we can call as the phase of awaking. However, the awaking procedure can be so fast, that the driver reacts in the panic form, with significantly increased probability of wrong decision and reaction.

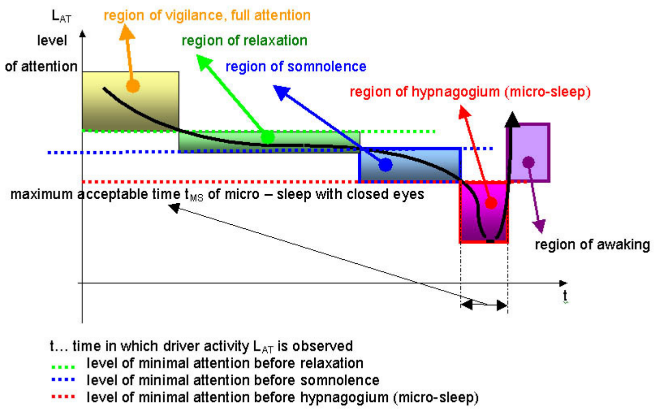

Fig. 2: Decrease of attention in the course of driver activity.

3. Warning Systems

Of course, in unhappy cases the accident can appear in any phase of driver attention. Nevertheless, the probability of accidents increases significantly when the driver is in the phase of somnolence or micro-sleep.

As concerns the phase of somnolence, to the driver remains still some part of his/her original ability of reliable driving, but if this phase lasts considerably long, there is increasing probability that also in this phase the driver can cause an accident.

As concerns the phase of micro-sleep, it lasts usually very briefly, and it ends either with transition in the phase of awaking or with accident. There is well known, that some very skilled drivers are able to keep the car on the road in straight movement when sleeping for some time, but they cannot react to external stimuli, namely of visual nature. Therefore, if some unexpected situation (e.g. some barrier or car staying in the traffic lane) appears on the road on which dormant driver in the stage of micro-sleep drives a car, there is no chance to prevent the accident, if no warning system is to disposal.

Warning systems can be constructed in various manners:

- Some of them can be oriented on the in-time recognition of the non-standard situation (barrier e.g.) on the road and consequently warning the dormant driver.
- The other type can be based on detection of the driver significant decrease of attention and on subsequent warning him/her that he/she is no more able to drive safely.
- Last kind of warning systems utilizes the ability to predict the driver attention decrease for reasonable prediction horizon and to warn him in advance, that he/she needs to relax.

Evidently, each kind has some positive features and some problematic ones. Therefore, it is recommended to combine them.

For any warning system the investigation of the reliability of interaction between the human subject and the artificial part of system is always very important. The demand on reliability of this interaction is stressed when a particular subject is exposed to the influence of a set of external stimuli, originating from the considered special kind of interaction between man and system, i.e., namely the case of the driver and transportation vehicle and/or the transportation system.

A set of such stimuli can be characterized as being very diverse, and changing significantly under the influence of various independent variables[7].

As concerns the case of driver-car interaction among the stimuli, which influence the car driver, the visual stimuli usually dominate.

However, from all of these signals influencing the driver, only some are really important for safe and reliable driving.

This is because the whole set of signals influencing the driver include, apart from those, which are represented by the observed external scene of the road and its environment, also involve the set of various other visual (and also acoustic) signals relating to the driver's observation of the interior equipment in the cockpit, as well as his/her interaction with it. Also the signals coming from driver communication with the car crew belong to this group.

Let denote the intensity of signals, which are necessary for reliable and safe driving as S_f (subscript f for functional).

These signals usually are mainly of the visual nature and originate from the driver's view on the road scene, not too far from the front of the car (usually in the distance of 10 to 100m ahead) and in observation angle about $\pm 30^0$ from the central line.

Some other signals disturb the subject's attention, dominantly concentrated on driving, and, therefore, have negative influence on the level of his/her attention devoted to the signals S_f. Let these, so called marginal signals be denoted as S_m.

In general the signals, with which the driver has to interact when driving the car on the road, can be classified in the following main groups:

a) Visual signals representing the observed external scene of the road and its nearest environment, which can have the influence on the situation in the front of the car or on both its sides;

b) Visual signals observed by driver in the rear and both side mirrors;

[7] (among the others, for example, the particular state of the considered artificial system, the level of its functional reliability, environmental factors; and, in each of the cases – the time)

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c) Acoustic signals concerning the traffic in the neighborhood of the car;
d) Acoustic signals coming from the car body and car engine;
e) Acoustic signals coming from the tires and wind;
f) Signals representing driver′s interaction with the car control tools and auxiliary cockpit equipments (communication and navigation before all);
g) Signals coming from the driver interaction with the car crew.

The first three groups can be considered as the components of the signals S_f, while the others form usually the set of signals S_m.

4. Indicators

The actual level of driver attention is the most important characteristic of his/her ability of safe and reliable control of moving car.

Unfortunately, up to now, there is known no simple, accurate and reliable tool for actual attention level L_{AT} measurement.

In general, as attention level indicators, very various physical or physiological parameters can be used. They are, of course, of different theoretical and practical value. As concerns the driver actual attention indication, among them the

1. face grimace,
2. eye movements,
3. breath temperature,
4. skin electric impedance,
5. hearth electric signals (EKG),
6. brain electric signals (EEG),
7. brain magnetic signals (MEG),
8. reaction time or speed,
9. observation angle,
10. probability of correct response,
11. hand-on-wheel vibrations,
12. declinations from ideal driving trajectory

are to be mentioned.

These attention indicators are of different significance. Some of them can be measured considerably easy; however the specificity and reliability of obtained data is of not too high level. Some other suffers from the considerably long delay between the actual change of attention level and the appearance of particular indicator change. In certain cases both these disadvantages combine. This concerns especially the indicators No. 1,2,3 and 4, which we therefore exclude from further considerations.

EKG signals (No. 5) should be taken into account, but their specificity as concerns the attention level is not enough high and therefore they are used as additional indicators only.

Indicators No. 6 and 7 are related to the most specific up to now known effect of the human brain, which is the electromagnetic field radiated by the myriads of neurons and other on the mental processes participating cells. From both, EEG and MEG signals almost the same information as concerns the attention level can be derived. However, the EEG signals can be measured now considerably easy, not only in the laboratory on car simulators, but also in the moving car, the measurement of MEG signals is still limited to the use of heavy, complicated and expensive equipments.

Indicators No. 8, 9 and 10 are of direct practical value and we can take them as the so-called direct indicators of attention level. Their values inform us immediately about the real ability of particular driver to drive safely and reliable. However, their direct measurement is usually based on more or less invasive approaches, disturbing the natural process of driver′s attention decrease and hardly applicable on the road. Therefore, though we use them for estimation whether the limits for safe driving are broken or not, we derive their values from other, so called indirect indicators.

Specific group form the indicators No. 11 and 12. They can be considerably easily measured even in the moving car, however the obtained values can be influenced by various disturbances, coming from the road surface imperfections and driving system properties. Nevertheless, their investigation is of very high importance.

Let us now concentrate to the so-called direct indicators before all.

In Fig. 1 and 2, the L_{AT} was considered as the scalar value.

Dealing with indicators No. 8, 9 and 10, we have to express the value of L_{AT} as the vector in the three dimensional space $\{L_{AT}\}$, having the axes RT^{-1} (speed of reaction), P_{corr} (probability of correct reaction) and α_{obs} (observation angle), see Fig. 3.

Of course the components RT^{-1}, P_{corr} and α_{obs} can be projected in the value of L_{AT} with various weights and transformations. For simplicity, let consider here the linear projection and equal weights.

In the course of time of human subject driving activity the vector L_{AT} follows in the space some curve $L_{AT}(t)$, the size and shape of which depends on other attention influencing factors of the physiological, physical and technical nature.

Some example of the $L_{AT}(t)$ curve is sketched in Fig.4. Here the sphere of the radius $|L_{AT\ min}|$ represents the limits, below which the value of L_{AT} cannot fall. In Fig. 4 the pink curve corresponds to the actual development of the attention. We see that it subsequently diminishes. However, this process is not smooth in general (see Fig. 1). Even in the case of fresh human subject after well sleep, considerably soon after his/her psychical and physical load by driving the attention level diminishes but occasionally can temporary increase. Considering the values of L_{AT} components RT^{-1}, P_{corr} and α_{obs} one finds, that their proportion in the actual level of L_{AT} varies also. If the curve of L_{AT} breaks the limit $|L_{AT\ min}|$, the driver is not more able to drive safely (see the red marked area in Fig. 4.

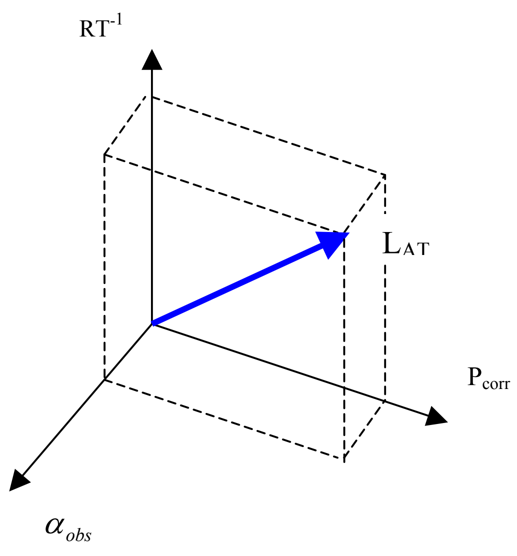

Fig. 3: To the expression of the level of attention L_{AT}

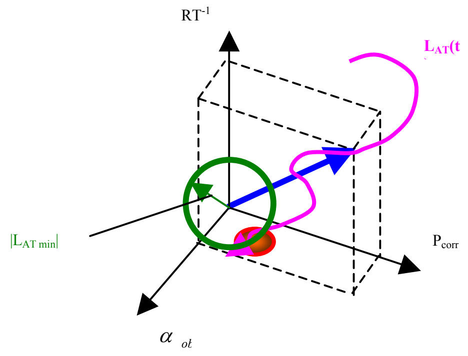

Fig. 4: The actual development of the attention and its limits

5. Attention Splitting

Obviously, from the above mentioned classification of the signals influencing the driver in course of his/her driving activity, only the groups a), b) and c) are directly important for safe and reliable driving. Of course, the division of all the driver influencing stimuli into the parts S_f and S_m cannot be straight and rigid. Actually, in the course of driving it changes with time and other independent variables.

In the linear approximation[8] each human subject has in any instant only a _limited capacity of his/her attention to disposal_, the presence of signals belonging to any of group of the S_m nature lead to splitting of the driver attention into two parts:

- that which is immediately concentrated to safe driving and
- that which is consumed by the sum of all the other marginal signals.

Let denote by $L_A(t)$ the actual level of driver attention in the time instant t in the period $t_0 < t < t_f$ (t_o represents the start time of driving, t_f represents the end time of driving).

The total attention disposable capacity C_{AT} of the particular human subject can be expressed as:

$$C_{AT} = \int_{t_0}^{t_f} L_{AT}(t)dt \quad \text{.......................................(1)}$$

The value of the integral (1) varies from driver to driver and depends also

- on his/her physical and psychical condition,
- on the type of the respective car,
- on the type of the road, traffic intensity and,
- on the conditions of driving.

In any case this disposable capacity is subsequently exhausted, of course not in monotonic manner. In the instant t_k only the part

$$Cr_{AT} = C_{AT} - \int_{t_0}^{t_k} L_{AT}(t)dt \quad \text{.................................(2)}$$

of this capacity remains.

[8] (probably the simplest model assumption)

The character of the C_{AT} exhausting varies with the type of driven car, with the situation on the road and with the others external circumstances (weather, illumination, radiation etc.)

If in the ideal case only the signals of the group a), b) and c) are present in the sum of actual signals influencing the driver, all the remaining capacity Cr_{AT} can be used for safe and reliable driving.

However, in practice, almost ever also the signals of the S_m nature are present. When at the instant t_k some marginal signals, i.e. those belonging to some of the groups d), e), f) and g) appear, the driver actual attention level splits in the part focused on driving and in the part oriented to marginal signals.

Let us consider the stimuli S_f as coming from the observed space not too far ahead in front of the car.

Nevertheless, situations may occur in which visual stimuli, coming from a wider distance, are of the major importance (e.g., the cases of very high speed driving, very complicated transport situations far ahead, etc.).

In addition to these front signals, the driver must observe also the situation on both sides of the road, and in certain road environments within appropriate proximity. Therefore he needs, at least temporary to widen his/her observation angle.

Let us denote:

- the intensity of partial visual signals concerning the transportation situation in front of the car as s_{fi},
and,
- the intensity of individual visual signals with regard to the marginal situation as s_{mj}.

The total intensity of visual signals coming to the driver's brain on the basis of the road observation can be then expressed as:

$$S_r = \sum_{i=1}^{i=n_f} s_{f_i} + \sum_{j=1}^{i=n_m} s_{m_j} = S_f + S_m, \quad \text{.......................(3)}$$

Where: $i = 1 \ldots n_f$ is the number of significant signals, and $j = 1 \ldots n_m$ is the number of marginal signals.

In (3) one supposes that:

a) all the partial signal intensities influence the driver's mind simultaneously, and
b) the relative weight of their acceptance is balanced equally.

This is, of course, an ideal case.

In reality, the no human subject can observe all the acting stimuli at once.

Detailed structure of the process of observing the complicated scene involving more partial stimuli is not completely known and it is in the focus of further investigation.

However, one can use the hypothesis, that all the recognized stimuli are stored in the driver short – term memory and that the driver attention is switched among its parts.

Thus, also the capacity and speed of switching between various parts of the driver short-term memory has to be taken into account in the course of the entire recognition process.

Suppose now for simplicity, that the driver attention is actually permanently switched only between the two parts of the short-time memory, storing temporary the above-mentioned two kinds of incoming stimuli of either the S_f or the S_m nature.

The dynamics of such attention switching is considerably complicated and its detailed analysis was not finished till now. In any case, it depends also on the intensity and character of the recognized stimuli (color, shape, size etc.)

For the purpose of this report an important is the necessity that when the driver reacts on some marginal signal, the detour his/her attention for some instant out of the main direction, i.e. the observing of the signals S_f and reaction on them, appears.

This attention detour can be a reason for various dangerous driving situations.

This is the reason, why we are interested in the ratio

$\nu = S_f / S_m$, ……………..……………..…………..(4)

And, namely in the ratio μ

$\mu = L_{AT_m} / L_{AT_f}$ ……………………………………….(5)

which represent the corresponding splitting of the drivers attention level L_A.

The case $\mu = 0$ could be an ideal case. Unfortunately, one cannot exclude the influence of marginal signals totally.

Actual values of the ratio μ are time dependent and varies between $0 < \mu \leq 1$. The case of $\mu = 1$ corresponds to zero attention given to the driving activity, which is a very unhappy, but in practice not quite excluded case. In such a situation the functional stimuli S_f are completely masked by the marginal stimuli S_m and the subject does not react on the S_f at all. The effect of stimuli masking is known and some very interesting experiments concerning it were presented in recent literature (see [1] e.g.).

The process of stimuli masking could surprisingly act also as some kind of "reverse attention splitting", when the subject, fully concentrated on some functional stimuli S_f completely ignores all the marginal signals S_m, even if some of them could be also of the importance for safe and reliable driving[9]. Therefore there is a strong interest to investigate the influence of the marginal stimuli and consequently to optimize the car cockpit arrangement and the driving conditions so, that the ratio of the attention degradation μ will be minimal.

6. Reliability Aspects

As was already mentioned elsewhere (see [3,4] e.g.), the ability for reliable and safe driving can be represented by some point in the multi-dimensional space {X} of the N parameters x_i representing the drivers attention level. In general various kinds of parameters x_i can be taken into account. However, because the determination of their values is very often loaded with considerably high level of uncertainty, the restriction of the number N to small values is recommendable [3]. For practical investigations, one deals therefore before all with two main parameters, representing the level of attention, i.e. the driver reaction time RT and the probability P_{corr} of his/her correct[10] response to certain external stimulus.

In the plane (RT, P_{corr}), the regions of acceptable attention are then restricted inside the gray shaded area, shown schematically in Fig. 5 (values of RF below 200 msec does not appear in practice, the RT above 1000 msec represent the fall into micro-sleep, or "hard" sleep) – (at the end of this article).

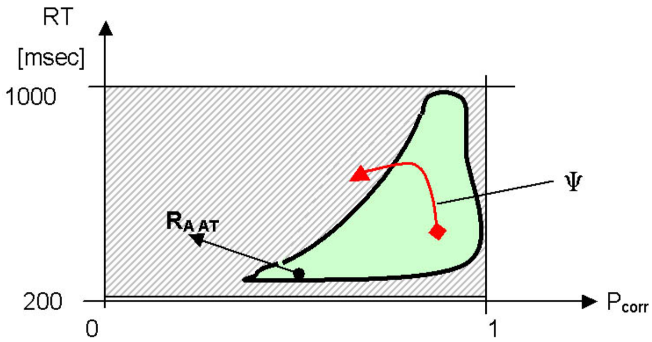

Fig. 5: The region of acceptable drivers level of attention and the respective life curve Ψ.

However, the investigation of the boundaries of $R_{A\ AT}$, even in such two-dimensional space represents a very laborious and complicated problem, especially because the various types of car, road, driving situation and especially also due the above mentioned drivers individuality has to be taken into account. Of course, often the boundaries of $R_{A\ AT}$ or some their parts have often more or less fuzzy character.

In the course of driving, the point $X = \{RT, P_{corr}\}$, representing the actual level of particular driver attention moves in the space $\{RT, P_{corr}\}$. It follows some curve, which in analogy to the technical system reliability theory can be called the "life curve" Ψ . This can be scaled by the values of various independent variables, namely by time. If the curve Ψ remains inside $R_{A\ AT}$ the driver is able to drive considerably reliable and safe. If it approaches the boundaries of $R_{A\ AT}$ or if it breakes it the situation becomes dangerous.

7. Advanced Training of Drivers

Another approach, how to diminish the number of accidents caused by decrease of driver attention consists in improving of driver training.

Much can be reached by the use of traditional methods, especially if they are completed by the systematic use of advanced driving simulators. However, the progressive training methods based on the use of simulators equipped by bio-feedback, if the training is realized in satisfactory repetitions and being controlled by skilled neurologist or psychologist can lead to significantly improved resistance to mood from driving activity. Such enhanced state of the particular person against fatigue can last considerably long, probably up to few years. In this period, the threat that his/her attention level falls down below acceptable level when driving is much less.

8. Optimization of Car Cockpit.

As concerns the car interior, much can be done optimizing the shape, position and kind of use of the tools for driving control – i.e. the driving wheel, pedals, gear handle, instruments on the cockpit panel etc. This optimization has to be provided not only with respect to driver convenience and comfort, however before all to reliability and safety of his/her interaction with the system of car, especially with its driving control. One of the most important aspect in this respect represents the optimization of the on-board mobile phone so that the mobile communication should have minimal negative influence on driver attention. The development and design of so optimized cockpit stay in the focus of interest of various leading car manufacturers.

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[9] (the driver fully concentrated to driving in complicated situation on the road can neglects – and really need not to mention - some stimuli coming from marginal situation on the road – e.g. the image of form side slow coming pedestrian or bike)

[10] Alternatively his/her wrong response ($1-P_{corr}$)

- In recent years there were realized several attempts how to design the on-board applicable system, which can automatically warn the driver against of his/her serious attention decrease and the advent of micro-sleep. Till now, however, no of them does reach the maturity for serious practical application. Nevertheless, there exists very high motivation for development of such warning tool.
- All the above mentioned approaches how to diminish the losses in traffic accidents fail, if there is no good will of the driver to use the respective warning tools and to follow the respective recommendations. Because of the drivers community consist unfortunately not only of the good willing people, but also of individuals of non-tolerant, careless, indolent, risky or aggressive nature, the system of general supervision of drivers behavior and of the respective punishment of eventual aberrances from given standards seems to be quite necessary. Of course, the development and introduction of such system into practical application represents very complicated problem, not only from the technical, but also from legal and juristic point of view. Nevertheless, the motivation to reach this goal is also very strong.

9. Conclusion

The operation of driver in moving car is an example of very complicated interaction between several very heterogeneous systems. Some of them are artificial, i.e. the car, the road (tunnel, bridge), the traffic control system, some are of real nature (driver, passengers, surrounding community, the controllers of traffic control system, police, justice). All of them interact in very complicated manner, which we at present are not able to analyze with necessary accuracy and reliability.

Even the relative simple interactions, like those between the driver and the moving car, sketched in Fig. 6 (at the end of this article) are not quite easy to understand.

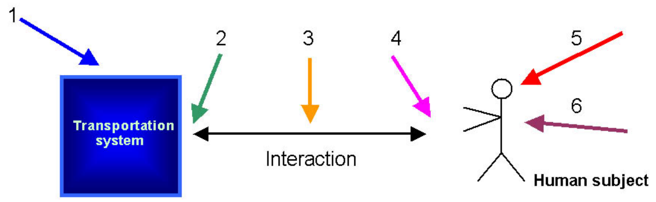

Fig.6: Structure of interaction transportation system – human subject.

Here denotes:

1…disturbing influences on transportation system, causing the decrease of interaction reliability

2… disturbing influences on interaction reliability caused by transportation system

3… disturbing influences on transmission and processing part of interaction

4… disturbing influences on interaction reliability caused by human subject

5… disturbing influences on interaction reliability caused by human subject mental activity

6… disturbing influences on interaction reliability caused by physical ability of human subject

Evidently, the solution of the above-mentioned challenges represents a very long research and development activity. Even if after much work some significant results will be reached, one cannot expect, that they will come fast in practical use in spite of there is evident strong need for it. This appears just because of natural inertia of our human society.

Nevertheless, we hope that subsequently we shall reach also some success in this respect and that we can so contribute to minimization of those tremendous dangers and losses, which we daily witness (or even act in) on our roads.

10. References

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