Distraction of Drivers: Causes, Effects, Prevention

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ABSTRACT: This paper concerns definitions, theory, causes, effects, and prevention of driver distraction. Internal and external stimulation on driver attention are analyzed. The simulation of driving is compared with driving under real conditions. The characteristics of older, as well as younger, drivers are given. The perspectives of preventive measures are presented from a technical, cognitive, and behavioural point of view.

KEY WORDS: distraction of drivers, preventive measures for accidents.

At present demands on a driver's attention are growing significantly, which is what brought us to selectively process new information regarding the causes and effects of so-called driver distraction, and to provide a theoretical, or possibly a model basis, for research along with its application (Štikar, Hoskovec & Šmolíková, 2010). For a long time, attention has stood at the forefront of the characteristics of drivers' mental activity during driving (Bena, Hoskovec & Štikar, 1962 and 1968, 2nd ed.).

Traditionally when we speak about distraction, we realize that often this refers to an unsuitable distribution of attention, or attention that is unsuitably focused. From a certain point of view, distraction in traffic can be understood as drawing attention away from activities that are important for safe driving (Regan, Lee & Young, 2009).

Attention can be distracted as a result of the driver's subjective condition, due to external stimuli, by other activities, such as telephoning, communication with passengers, and by thoughts that do not concern driving, as well as others. We call these secondary activities. During an analysis of 100 accidents or near-accidents in relation to secondary activities during driving, Dingus et al. (2006) determined the order in which individual activities are distracting among 241 drivers. The most distracting was found to be information from various devices and manipulation with other passengers, distraction caused by external stimuli outside of the vehicle, talking to oneself or singing, personal hygiene, daydreaming, and smoking. Attention must be related especially to perceptual processes (central and peripheral). Attention can fail during central vision, when the object can be visually perceived, but the brain is not aware of it. Attention can fail during peripheral vision due to insufficient or inflexible searching.

1   THEORETICAL APPROACH

Driver distraction causes many accidents; the concept of selective attention is essential for important theoretical constructs of cognitive ergonomics, including situational awareness and workload. It is necessary to provide a framework for uniting expert approaches,

which will show the direction for future research and implications for interventions proposed for lowering the number of accidents. Fundamental features and findings are summarized, which illustrate the key principles. Enns and Trick (2006) divide the topic into three parts: the first one presents two global dimensions that serve as the basis for this framework; the second describes the framework and summarizes four ways of choosing information; the third part deals with practical effects for accident prevention.

Selective attention is considered to be indispensable, because our surroundings consist of too many objects to be perceived in one moment and to which we can react. At present, however, basic research lacks a general theory on selective attention. Instead, there are closely focused theories related to specific activities, for example visual searching, filtering, carrying out several activities at once (dual tasking), and watching several objects. Varying performance during these activities reflects the presence of two elementary dimensions of selection on the basis of focusing attention.

The first dimension deals with awareness and includes the differentiation between automatic and controlled processes. Specifically there are two ways in which the selective process can function. First mode: stimuli and reactions can be selected without awareness. Selection without awareness has been described by various authors as pre-attentive, subconscious, and unintentional. Regardless of these terms, this type of selection is automatic. Automatic selection is quick, it does not require any effort, it is subconscious, and as soon as the process begins, it is difficult to stop it or alter it. These processes are triggered by the presence of certain stimuli in our surroundings and they run till the end without interrupting any other processes. Second mode: Stimuli and reactions can be selected on purpose, with awareness. Selection with awareness (variously called attentive, conscious, or deliberate) includes controlled processing, which indicates that this form of selection is rather demanding and slow. However, it is possible to start it wilfully, or to stop it or alter it, which is a feature that makes this type of processing flexible. Controlled processes can cause changes in long-term memory through learning, and with proper practice some types of controlled processes can even become automatic. The fundamental problem of controlled processing lies in the fact that it is demanding to perform several controlled processes at once. Distinguishing between automatic and controlled processing is often discussed as if there were a strict dichotomy. Enns and Trick (2006) think that it is probably more useful to consider them as a continuum. Some processes are more automatic than others in the sense that they commence more quickly, they require less effort, they are more likely evoked unintentionally in the given situation, and therefore it is more difficult to get them under intentional control.

The second dimension deals with the origin of the attention process, whether it is given at birth and thus common to all people (exogenous), or whether it was created due to the specific aims of an individual (endogenous). Exogenous selection arises from human biological nature. The nervous system is structured in a way that allows it to react preferentially to some stimuli; hence there exists an innate continuum of significance of stimuli, with some types of stimuli becoming the object of exogenous selection with a greater possibility than others. On the other hand, endogenous selection arises from our knowledge of our surroundings and from what people wish to achieve. It is specific to each situation. People actively seek out information in their surroundings that is relevant for their specific goals or intentions, and they perform these acts in ways that are in compliance with their expectations and previous learning. These expectations may function as a kind of "perceptual set", which causes people to search for specific objects in specific places. Lim et al. (2004) describe a model of driver's visual attention which gathers information on the basis of selective processes so that it would be possible to model effects such as distraction. This model includes the ability to gather visual

information, and the mechanisms of visual attention, on the basis of subjective and objective factors. Due to the fact that the research was focused on its practical application, the model was designed so that it could be integrated as a component processor within a computer traffic simulation. The model determines visual attention with the help of two mechanisms: internal and external focusing. The mechanism for internal focusing is a proactive attention regulator. This subjectively founded mechanism moves the head and eyes in a general direction so that relevant information for the given task is actively sought out on the basis of the driver's expectations. Mechanism of external focusing is a reactive attention regulator founded on the basis of the characteristics of objects in the driver's field of vision. External control allows for the modelling of distraction, because irrelevant information may objectively require more attention than relevant information. These two controlling mechanisms determine the attention demand value (ADV) of each visible object. Therefore, we receive visual information from the object with the highest ADV. ADV also plays its role in determining the time needed for processing information and the amount of attention that is reserved for driving. By using this model and the possibility of various internal and external input variables, it is possible to simulate various types of drivers with different visual abilities (for example, in relation to age or intoxication) in an environment full of detailed visual information.

2 A REVIEW OF ATTENTION DISTRACTION IN DRIVERS

Young, Regan, and Hammer (2003) provide a complex review of research results concerning the distraction of driver's attention coming from the vehicle's interior. They examine the effect of technology (e.g., mobile telephones and navigation systems) and nontechnical distractions (e.g., food consumption, smoking, and talking to other passengers) on driving performance, and they deal with the relative effect that these distracting elements have on driving. It is estimated that about one quarter of car accidents in the United States are caused by drivers' inattention or distraction. Results from research (Ho & Spence, 2008) lead to an overview concerning mobile telephones, navigation systems, e-mail and internet devices, entertainment devices, and nontechnical distraction. In brief, there is consistent evidence that attention distraction caused by technology and other stimuli may have a negative influence on a driver's performance. The degree to which distraction threatens safety is, nonetheless, dependent on the frequency with which the driver is subjected to the given distraction, and on specific driving conditions.

Electronic systems are even used in the form of external billboards. In their report, Farbry et al. (2001) present a summary of research findings regarding the possible safety consequences of electronic billboards during driving. The review covers the period between the publishing of a similar text in 1980 up to the year 2000. Gaps in our knowledge were identified on the basis of literature research, and sets of research questions and related research findings were put together on their basis. Research questions are categorised into road characteristics, e.g., turns, crossings, and work zones; billboard features, such as the length of time that a picture is displayed, movement, and the readability of the advertisement; characteristics of drivers, e.g., knowledge of the area and age. It also includes related findings from research carried out on the readability of information boards regarding various types of traffic information.

3 RESEARCH IN REAL AND SIMULATED CONDITIONS

Apart from the review of research results regarding driver distraction caused by technology or other stimuli coming from the interior of the vehicle, Young, Regan, and Hammer (2003)

examined various methods used to measure the distraction of drivers and to measure driving performance (e.g., keeping to one's traffic lane), which seems to be easily influenced by various types of distractions. The following scientific methods for measuring attention distraction were identified: research studies on roads and test routes, research studies carried out on driving simulators, studies on dual tasks, studies monitoring where eyes are focused, visual method for verifying when eyes are taken off the road, and the detection of peripheral impulses.

The outcome of this review shows that rather than using just one method, it is suitable to use a set of methods for measuring attention distraction when evaluating the proposed concepts of devices in relation to human machine interface (HMI) and prototypes of vehicles. The technology applied or the selected sets of methods will depend on the specific aspects of HMI, which are to be evaluated, and especially as regards the form of distraction that distracts the driver's attention within the given interface. Conducting research on roads is more dangerous and it is less experimentally controlled than studies conducted on simulators.

Studies carried out in real conditions allowed experts to create a model of drivers' behaviour during rear-end crashes, which was based on attention (Brown, Lee & McGehee, 2000).

The research of Reimer et al. (2007) is an example of a study conducted on a simulator. They examined the participation of adult drivers with Attention Deficit Hyperactivity Disorder (ADHD) in traffic accidents and of control group drivers in a simulated experiment, which was designed to increase the effects of tiredness. Due to the fact that symptoms of ADHD include problems with maintaining attention, it was assumed that drivers with ADHD would be more prone to the effects of tiredness during driving. The data was received from a validated study of driving simulation, and its parts were focused on the increased effect of fatigue. The data received from the simulator were supplemented by written data received from questionnaires. Drivers with ADHD were compared with the control group. Results indicate that drivers with ADHD get tired more quickly than drivers from the control group. These drivers then face a higher risk of car accidents on highways or on roads with an open view, where the visual monotonousness of the environment and routine tasks contribute to the greater tiredness of drivers.

Another example of attention research carried out on simulators is a study by Benoit et al. (2008). They propose developing a driving simulator that would take into consideration information regarding the user's state of mind (concentration of attention, states of tiredness or stress). The analysis of the user's state of mind is based on data from a video and on physiological parameters.

Nakayasu et al. (2007) researched how drivers perceive information regarding danger in selected traffic situations. The relationship between visual attention and the extent of the useful visual field was examined by measuring eye movement during simulated driving.

4   CATEGORIES OF CLASSIFICATION

Diverse schemes of classification are created in different countries (Gordon, 2005). When we speak about distraction, experts have a tendency to describe the character of distraction according to four types, which include various sources and modes of sensory perception (e.g., Young, Regan & Hammer, 2003). These four types are:
Visual distraction: source of distraction and/or the form of attention are related to sight;
Auditory distraction: source of distraction and/or the form of attention are related hearing;

Physical distraction: the driver performs physical movements, which typically means taking one or both hands off the steering wheel, the manipulation of something.

Cognitive distraction or mental diversion of attention: source of distraction and/or form of attention are related to cognitive processes, e.g., being "absorbed" by something or by some mental activity.

Let us add *emotional distraction* to these four as the fifth type. Behaviour connected with distraction usually includes several sources and ways of distraction. Picking up a mobile phone for example (reaction to an auditory signal, picking up and manipulating the phone, conversing or reading, and consequently hanging up and returning the telephone to its place) can include all types during the whole process. However, it is important to note that distraction is not only about information overload and opposing requirements, but it also includes the limits of human perception and the failure of controlling processes, such as feedback, planning, and predicting "events" (Lee, 2005).

An important difference between a source of cognitive distraction and other sources of distraction seems to be the amount of time that the given behaviour lasts. For example, various types of behaviour that distract attention, such as moving an object from one place to another, changing a CD/ radio station, are very isolated activities and are limited by time and also by the given task. Other distracting behaviours, such as conversing with a fellow passenger or smoking, may last a long time and take up a large part of the journey. If someone gets into a car after an argument or is stressed and is thinking about the day that has passed, it is possible to say that this person is cognitively inattentive and distracted, and it is better to describe attention distraction as a "state" we can find ourselves during our journey. The definition of distraction by Regan (2005) is apparently able to include cognitive distraction as, for example, being preoccupied by a certain thought, since such distractions can be considered to be secondary activities which can last throughout the whole journey; these are focused on the driver and certainly can disrupt performance of the primary task, which is driving.

5   DRIVERS´ AGE

Tuttle et al. (2009) compared the attention of older and younger drivers. Groups of younger drivers (N = 49, average age = 21.7 years) and older drivers (N = 52, average age = 73.0 years) performed cognitive tests and driving simulation. Results from cognitive tests were subjected to Principal Component Analysis (PCA), out of which 6 components arose: speed, divided attention, sustained attention, executive attention, selective attention, and visual search. Scores for individual components were used for anticipating performance during simulated driving. Results showed that speed and divided attention explain the differences in driving performance with a greater probability.

Mourant et al. (2001) used a task, during which it was necessary to distribute attention, in order to measure younger and older drivers' ability to obtain information from a display placed in a vehicle. Performance when using a display in the vehicle was compared with performance when information was transferred onto a driving scene image on simulator. Older drivers were less exact when receiving information from the display inside the vehicle, the average position error in a driving lane was higher among older drivers and older drivers spent more time driving outside of their lane. These results indicate that using displays inside cars in their current configuration is not suitable for older drivers. When following information transferred onto a driving scene, older drivers were much more exact and had better control of their cars. This fact shows that the low performance of older drivers when using displays inside cars is caused more by changes in vision, e.g., a longer period is needed for the eye to adapt, than by cognitive processes.

Visual attention and behaviour during driving among older people was monitored by Richardson and Marottoli (2003). Their research study was designed with the aim to specify those cognitive variables that are connected to the specific behaviour of drivers on roads in a sample of active drivers older than 72 years. The driving score significantly correlated with the performance tests of visual attention and visual memory. Visual attention, which is a cognitive function that includes searching, selection, and switching, plays an important role in the risk related to older drivers. Visual attention is mostly connected to key driving manoeuvres, which include interaction with other vehicles/pedestrians, e.g., giving right of way and safely making a turn in the traffic. Specification of cognitive risk factors, as well as their effect on problematic driving manoeuvres, may give us a lead for the development of targeted interventions to lower the risk in older adults.

6 PREVENTION

Due to the fact that the factors supporting the occurrence of distraction are, for example, tiredness or the consumption of alcohol, research focused on the development of tools that would detect these factors as well. Regan, Lee and Young (2009) give a whole set of techniques to proceed against distraction. Many proposals are engineering-psychological, that is the adaptation of interior and exterior devices that provide information. These authors even focus on alerting drivers when they do not realize their state of distraction. Some automobile producers especially, such as Saab (Nabo, 2009), are trying to develop and apply this kind of technology.

Loss of control occurs when the driver diverts his/her attention from driving, if only for a couple of seconds. In order to drive safely, it is necessary to continuously pay attention to driving. At the same time, it is well known that people easily divert their attention or even become sleepy when driving.

Other intelligent transportation systems are also being developed which should help drivers and which should secure a safe environment on the roads. One approach to designing ergonomic automobile systems is to incorporate our understanding of human systems for processing information into the process of designing. It is necessary to support the designing of ergonomic interfaces that include several senses by using research from the fast-growing field of cognitive neuroscience. These focus mainly on two aspects of information processing among drivers: interaction that includes several senses and the special distribution of attention during driving (Ho & Spence, 2008).

A review of international standards and the design of devices for vehicles that can influence attention is given in the 7th part of the Regan, Lee and Young (2009) publication. Data received from the European Union are compared with data from the USA and Japan.

Research conducted in the form of group discussions gives certain indications of how drivers consider questions concerning driver distractions and other strategies which they think could be used to lower possible risks. In connection with the research on the effect of distraction on driving and on the limits of human attention this research indicates that drivers can realize only some of the problems comprised in this topic. It is necessary to conduct further research focused on the monitoring of drivers' behaviour inside the vehicle.

Research conducted in the form of group discussions indicates that the public partially understand how distraction influences driving, and people presume that they are capable of performing a lot of these activities as a regular part of driving. Taking into account the aforesaid, providing information about how distraction works and about the risks of various distracting behaviour could at least increase awareness, and it would be possible to give advice and instructions for applicable behavioural solutions, e.g., in programmes for driver training. For example, some types of distraction could be prevented by better

planning, i.e., by securing objects on seats before driving. With other distractions, it is possible to use a behavioural strategy in which people should be encouraged to change their habits and behaviour, which can include a combination of practice, training, and programmes for raising awareness, and/or stimuli coming from the surrounding environment (e.g., legislation or enforcement).

When training drivers, it is important to repeatedly emphasize that many distractions are related to events/objects outside the vehicle, such as landscape and other people, and that there are many distractions coming from inside the vehicle, such as objects brought by the driver with him/her into the car, that have nothing to do with technology. Moreover, we bring technical devices into the vehicle, e.g., telecommunication devices, portable computers, or entertainment devices, which were not developed with the intention of being used during driving. If we add other tasks to our elementary driving task, the complexity increases and this may sometimes catch us off guard. The less secondary tasks there are, the better.

A significant factor that influences distraction is so-called self-regulation. We recognize strategic self-regulation, e.g., not using a mobile phone when driving, or operational self-regulation (lowering our speed).

Training and educational programmes exist that support attentive driving. As part of these programmes, it is also possible to make use of results from experimental research (Metz, 2009) on improving attention performance in more demanding situations, e.g., when driving through complex intersections.

Mills (2010) promotes an approach called disciplined attention. This approach has one goal – to lower the number of car accidents. The course develops safe driving styles. Disciplined attention is a new term used in training drivers. It starts with visual and cognitive demands placed on drivers at all levels of experience, from beginners to experienced professionals. The course of disciplined attention draws information from modern science, as well as from top driving school instructors.

REFERENCES

Bena, E., Hoskovec, J., Štikar, J., 1962, 1968, 2. vyd. *Psychologie a fyziologie řidiče*. Praha: Nadas. (in Czech)

Benoit, A. et al., 2008. *Multimodal focus attention detection in an augmented driver simulator, Personal and Ubiquitous Computing* [online]. Retrieved from: www.enterface.net

Brown, T. L., Lee, J. D., McGehee, D.V., 2000. *Attention-based model of driver performance in rear-end collisions: Annual Meeting of the Transportation Research Board No. 79.* Washington, D.C.: INIST-CNRS.

Dingus, T. et al., 2006. *The 100 – car naturalistic driving study, Phase II: Results of the 100 – car field experiment,* Report DOT HS 810-593. Washington, D.C.: National Highway Traffic Safety Administration.

Enns, J. T., Trick, L. M., 2006. Driving and selective attention: Four modes of selection. In Bialystok, E., Craik, I. M. (Eds.). *Lifespan cognition: mechanisms of change, Chap. 4*, Oxford: Oxford University Press.

Farbry, J., et al., 2001. *Research review of potential safety effects of electronic billboards on driver attention and distraction: Final Report*, September 11. Washington, D.C.: Office of Safety Research and Development, Federal Highway Administration.

Gordon, C., 2005. *Driver distraction: An initial examination of the „attention diverted by" contributory factor codes from cash reports and focus group research on perceived risks.* Paper presented at the September 2005 IPENZ Conference in New Zealand.

Ho, C., Spence, Ch., 2008. *The Multisensory Driver*: *Implications for Ergonomic Car Interface Design*. London: Ashgate. 158 p. ISBN 978-0-7546-7068-1.

Lee, J. D., 2005. *Driver distraction: Breakdown of a multi-level control process*. Paper presented at the Driver distraction conference, 2-3 June, Sydney.

Lim, C., et al., 2004. A driver visual attention model, Part 1. Conceptual framework. *Canadian Journal of Civil Engineering*, vol. 31, no. 3, pp. 463-472.

Metz, B., 2009. *Worauf achtet der Fahrer? Steuerung der Aufmerksamkeit beim Fahren mit visuellen Nebenaufgaben, Dissertation*, Würzburg, J.- M.- Universität.

Mills, K. C., 2010. *The disciplined attention driver education program* [online]. Chapel Hill, NC (USA): Profile Press. Retrieved from: http://alertdriver.com

Mourant, R. R. et al., 2001. *Measuring divided-attention capability of young and older drivers, Transportation Research Record No. 1779*. Washington, D.C.: Transportation Research Board.

Nabo, A., 2009. *Driver attention – dealing with drowsiness and distraction*, Saab Automobile AB report.

Nakayashu, H. et al., 2007. Measurement of visual attention and useful field of view during driving tasks using a driving simulator. In *Proceedings of the 2007 Mid-Continent Transportation Research Symposium*. Ames (USA): Iowa State University.

Pradhan, A. et al., 2009. Attention maintenance in novice drivers: Assessment and training. In *Proceedings of the fifth international driving symposium on Human factors in driver assessment, training and vehicle design*. Iowa City, IA (USA): University of Iowa.

Regan, M., 2005. *Driver distraction: Reflections on the past, present and future*. Paper presented at the Driver distraction conference, 2-3 June, Sydney.

Regan, M. A., Lee, J. D., Young, K. L., 2009. *Driver distraction. Theory, effects and mitigation.* Boca Raton, FL (USA): CRC Press.

Reimer, B. et al., 2007. Task-induced fatigue and collisions in adult drivers with attention deficit hyperactivity disorder. *Traffic Injury Prevention*, vol. 8, no. 3, pp. 290-299.

Richardson, E. D., Marottoli, R. A., 2003. Visual attention and driving behaviors among community- living older persons. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, vol. 58, no. 9, pp. 832-836.

Štikar, J., Hoskovec, J., Šmolíková, J., 2010. Nepozornost řidiče. In *Zborník Transport Psychology – Trends, Medzinárodná vedecká konferencia z dopravnej psychológie*. Bratislava: CZU, pp. 114 – 124. (in Czech)

Tuttle, S. et al., 2009. Attention function structure of older and younger adult drivers. In *Proceedings of the fifth international driving symposium on Human factors in driver assessment, training and vehicle design*. Iowa City, IA (ISA): University of Iowa.

Young, K., Regan, M., Hammer, M., 2003. *Driver distraction: A review of the literature, Report 206*. Melbourne (Australia): Monash University Accident Research Centre.