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THE EFFECT OF COGNITIVE LOAD, AGE AND DRIVING EXPERIENCE ON PROCESSING TIME IN AN EXPERIMENTAL TRAFFIC TASK

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Abstract

The general goal of this research was to examine risk factors in traffic that are related to the individual's cognitive abilities. Attention is very important for driving, because it allows us to focus our mental activity on selected information and neglect other irrelevant ones. But, attention has a limited capacity. During driving, the driver is affected by numerous distractors that can absorb available attention resources and make it difficult to process relevant data. Accordingly, we wanted to examine how increasing cognitive load affects reaction time in an experimental "traffic" task. We manipulated the cognitive load by adding another, auditory, task to the primary visual task, as an analogy with frequent distractors while driving, such as talking to a passenger or using a mobile phone. We also wanted to examine whether the effect of cognitive load differs among drivers of different ages, given that perceptual and cognitive changes occur as people get older. But, along with age, we also analyzed years of driving experience, because research has shown that this is an important aspect of driving behavior. The sample consisted of 279 drivers (M=26,9, SD=8,6) who voluntarily participated in the research. There were three factors in the study: cognitive load, age and driving experience. Reaction time was measured in an experimental task from the traffic domain, that was created in Psytoolkit online platform. The obtained results show that there is a main effect of cognitive load on reaction time. Subjects who had an additional task had an extended reaction time in the traffic task. There is also statistically significant interaction between cognitive load and age. When the cognitive load of a new task increases, younger drivers (younger than 33) react more slowly in the traffic task, while this is not observed in older drivers. An effect of driving experience on the RT is statistically significant. Subjects with the least driving experience have the shortest reaction time. The obtained findings indicate differences between drivers in cognitive information processing mechanisms and can be explained by the attention capacity model.

Keywords: *Cognitive load, driver attention, age, driving experience, processing time.*

1. Introduction

Driving is a complex activity that involves the integration of sensory information and their coordination with motor actions. In an attempt to explain driving activity, Rumar (1985) created a model that includes basic perceptual functions, limited cognitive capacities, memory and motivation. He particularly emphasized the importance of perceptual and cognitive errors that can significantly reduce road safety. With ideal vehicle performance and road conditions, a large number of accidents are caused by those human factors. A cognitive process that is particularly important for driving is attention. It is defined as a brain mechanism for selecting relevant information or as a cognitive state that is constantly changing and characterized by selectivity, intensity and dynamic character (Van Zomeren & Brouwer, 1994). Attention also functions like a spotlight because it enables the fastest processing of information that is in its focus (which is best "illuminated") (Posner, 1978). While driving the driver may be faced with a large number of distractors that can affect traffic safety. The most common distinction is made between visual, manual and cognitive components of distractors (Victor, Engström, Harbluk, 2008). Distraction is a phenomenon of inattention that causes a delay in recognizing and processing information that is necessary for the successful performance of a driving activity. Distraction refers to the various situations of dispersion of the driver's attention due to the fact that the driver temporarily focuses on something (object, person, task or event) that is not related to his driving. This can cause a delay in recognizing and processing information necessary for safety traffic (Hedlund, Simpson,

& Mayhew, 2006). The most researched distractor while driving is the use of the phone and the cognitive load associated with it. Driver's cognitive workload is defined as cognitive resources that are taken from the driver by any activity other than the driving itself (Engström et al., 2017). In the study of the impact of using a mobile phone as a distractor, the authors (Strayer & Johnston, 2001) indicated that it includes two aspects of attention engagement. The first refers to physical manipulation of the device itself, such as unlocking the phone, typing letters on the keyboard, typing or dialing a number from the contact list. Another aspect of engaging attention is related to communication - the process of exchanging information through a certain sign system that represents a form of "cognitive activity". The results of this research showed that the use and conversation on a mobile phone influenced the reduction of the number of accurate detections of traffic signs. This confirms the assumption of cognitive load and occupation of available attentional resources, which leads to interference in the processing of other relevant information.

Age can also be a significant factor in driving safety. As we get older, there are changes in perceptual and cognitive processes, which can significantly affect driving itself. Older drivers have more accidents due to sensory and decision-making processes, but younger drivers, on the other hand, participate in accidents due to excessive speed and risk taking (Verhaegen, Toebat, & Delbeke, 1988). Compared to older drivers, younger drivers report more frequent distractions while driving and increased fatigue (Lyon et al., 2020).

Experience is an important aspect of driving activity. Although most often there is an overlap of age and years of driving experience, there are also exceptions where a greater number of years of age is associated with a smaller number of years of driving practice. This usually occurs if an individual opts for driver's training in older adulthood. Research shows certain differences in driving behavior in relation to experience. Patten et al. (2006) found that inexperienced drivers have an increased reaction time to peripheral stimuli. They also have simpler and static patterns for recognizing traffic situations (Boy, 1998). Crundall and Underwood (1998) found that experienced drivers have greater variations in eye fixations on horizontal axes. Experienced drivers also chose appropriate visual strategies in relation to the type of road.

The main goal of this research was to examine the effect of cognitive load, age and years of driving experience on reaction time in a experimental traffic task. On the most general level, the research enables examination of risk factors in traffic that are related to the individual's cognitive abilities.

2. Methods

Two hundred and seventy-nine respondents, active drivers from the territory of Republika Srpska, aged from 19 to 55, participated in the research. Of the total number of participants, 104 were female. The experimental procedure was created in the online platform Psytoolkit. It consisted of four trials. In each trial, an intersection with vehicles was shown, and the subject's task was to determine which vehicle had the right of way. Reaction time was measured in each trial. An example of stimuli (traffic situations) is shown in Figure 1. The artistic and graphic preparation of the stimulus was done by Mirjana Despot (graphic designer).

Figure 1. Example of experimental stimulus.

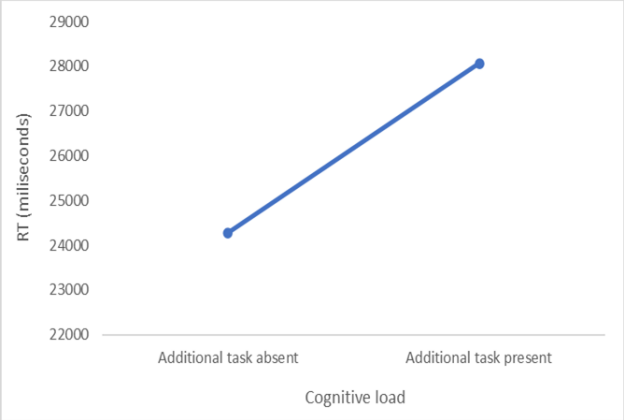
In order to examine the effect of cognitive load on the performance of the traffic task, an additional task was introduced for one group of participants. It was presented in the auditory sensory modality and consisted of the presentation of a word (color name) in intervals of 500 milliseconds, during which the participant had to keep track of how many times the word "blue" was spoken. This kind of experimental manipulation was introduced by analogy with the use of a mobile phone while driving, which is related to receiving information from the sense of hearing, and requires a certain cognitive

engagement. Through randomization, the participants were assigned to one of two experimental conditions (without additional task and with additional task). In addition to the experimental task, all participants also filled out a follow-up questionnaire that collected data on age and years of driving experience.

3. Results

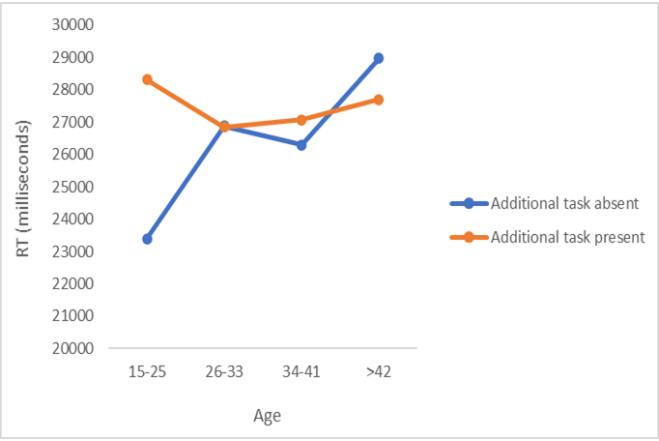
Analysis of the obtained data shows that there is a main effect of cognitive load on reaction time $F(1,279) = 26.741$, $p < .001$, $\eta^2 = .088$). Participants who had an additional task had an extended reaction time in the traffic task (Figure 2).

Figure 2. Reaction time depending on the cognitive load.



Results also show that there is statistically significant interaction between cognitive load and age $F(3,279) = 3.168$ $p < .05$, $\eta^2 = .034$). When the cognitive load of a new task increases with adding a new task, younger drivers (< 33 years) react more slowly in the traffic task, while this is not observed in older drivers (Figure 3).

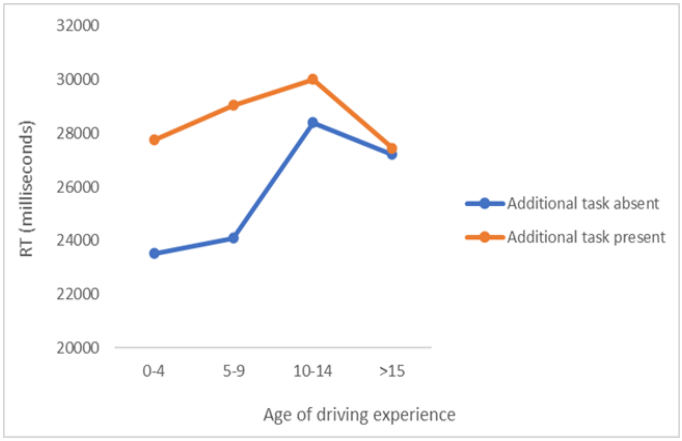
Figure 3. Reaction time depending on cognitive load and age.



Analyse of driving experience effect shows borderline statistical significance $F(3,279) = 2.420$, $p = .06$, $\eta^2 = .026$). Subjects with the least driving experience have the shortest reaction time, while the longest reaction time is present in drivers with 10 to 14 years of driving experience.

When the experimental factor (existence/absence of an additional task) is included in the analysis, the distribution of reaction times differs to a certain extent (Figure 4).

Figure 4. Reaction time depending on cognitive load and driving experience.



Although no statistically significant interaction between driving experience and cognitive load was obtained, individual comparisons between groups show that in drivers with up to 4 years of driving experience and those between 5 and 9 years, the reaction time in the task increases with the addition of another task.

4. Discussion

This study provided empirical data on the functioning of human cognitive processes in the context of a traffic task. The driver must select, process, encode and store or retrieve information in order to make the right decision in traffic. If an error occurs in that series of operations, driving safety is significantly reduced. Even greater problems can arise if the driver is affected by a large number of distractors that can make it difficult to process important information. In psychological research, this is known as cognitive load, and it is mainly examined during a dual-task experimental paradigm. Starting from the assumption that increasing the difficulty of tasks leads to an increase in cognitive load, we wanted to examine what effect it has on reaction speed in an experimental task from the domain of traffic. We also wanted to examine whether this effect is the same in drivers of different ages, as well as different years of driving experience. The obtained results show that cognitive load significantly affect reaction time. Drivers who had an additional task had an extended reaction time in the traffic task. By increasing the cognitive load, a larger part of the available attention resources is engaged, which leads to a slowdown in the processing of relevant information. This can be explained by the attention capacity model.But, significant interaction between age and the experimental manipulation was also found and it indicates that the effect of cognitive load is not the same for all participants. When the cognitive load of a new task increases, younger drivers (younger than 33) react more slowly in the traffic task, while this is not observed in older drivers. Such results can be explained by the findings of Lundqist and Eriksson (2019), who showed significant positive effects of bimodal warning in a car. The additional task in our research belonged to the auditory modality, so it is possible that older drivers integrate information from different sources more easily than younger ones.

A similar explanation could be given for the effect of cognitive load on subjects with different driving experience. The most negative effect of the additional task can be observed in participants with fewer years of driving experience. Over many years of practice, drivers bring certain actions to a level of automation and more easily integrate information from multiple sensory systems. The results of earlier research also show that novice drivers, compared to more experienced drivers, have a longer processing time and a narrower scope of visual search, as well as that more experienced drivers manage better on more demanding sections of the road (Crundall & Underwood, 1998; Underwood et al., 2002), which can partially be applied to our results.

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