2014•2015
SCHOOL FOR TRANSPORTATION SCIENCES
Master of Transportation Sciences

Master's thesis

Effect of social pressure on driving ability of older drivers

Supervisor :
Prof. dr. Tom BRIJS

Co-supervisor :
dr. Ellen JONGEN

Veronika Rudnenko

Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences

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Universiteit Hasselt | Campus Diepenbeek | Agoralaan Gebouw D | BE-3590 Diepenbeek

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PREFACE

This document represents the findings of the research dedicated to investigation of effect of social pressure on driving ability of older drivers, completed by Veronika Rudnenko, the 2nd Master student of Transportation Sciences (Traffic Safety), under the supervision of dra. Ariane Cuenen.

The research is triggered by several reasons. First, it is the growth of the population of older drivers. It is not only the question of amount of active older drivers, but also the fact that they continue driving for longer period of time than before. Second reason is the absence of comprehensive scientific researches that investigate the response of older drivers to the social pressure on the road. Therefore, the research was initiated in order to provide better understanding of this problem.

In general, the whole process is divided in two parts, which are theoretical (literature review) and practical (data analysis). Both of them are finished and results are presented in this paper.

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SUMMARY

This report consists of two parts, which are theoretical review of the literature and data analysis. It includes four chapters: 1) introduction, 2) literature review, 3) experimental design, 4) discussion, and 5) conclusion.

1) Introduction

This part includes short description of the main points of the research, which are the reason why the study was initiated, and the goal of the study.

2) Literature review

This chapter includes four subsections. The idea of the structure is the following: the problem definition (*Effect of Social Pressure on Driving Ability of Older Drivers)* is first divided in two independent parts, which correspond to first two subsections 2.1) driving ability of older drivers, and 2.2) what is stress? First subsection explains the general problem of population aging, its effect on the driving performance and driving safety. Second subsection provides the general description of stress, its reasons, stages, effects and influence on performance (in particular, on driving performance). Stress for this research is considered to be a behavioural response of the driver to the social pressure on the road. The main concepts of first two subsections are combined in the 2.3) stress effect on driving ability of older drivers. This section covers the complete content of the research problem. It describes age and gender differences in stress arousal; then, it explains the stress factors in driving, one of which is social pressure. The subsection finishes with the definition of tailgating as the type of social pressure on the road. The last subsection 2.4), based on three pervious, formulates the research questions and hypotheses.

3) Experimental design

Firstly, the sample is described, followed by the research method and explanation of additional tasks and questionnaires. Secondly, the analysis of collected data includes descriptions of applied statistical analyses, followed by the in-depth investigation of subjective and objective driving performance based on the presence of social pressure on the road.

4) Discussion

In this part, the main outcomes of the data analysis are discussed towards the results of related empirical studies. Objective and subjective driving measures are described separately. This discussion is followed by the study limitations, possible implications of the obtained results and recommendations for future research.

5) Conclusion

This part includes the main findings and conclusions that follow from the literature review. It also describes the future expectations from the next steps of the study.

1. INTRODUCTION

Global demographic situation predicts a rapid growth of the older people population (Morgan & King, 1995; Aplin, 2009). In comparison with 1999, the number of older people already showed an increase of more than 20%; before 2025, elderly drivers will substitute more than 18% of active drivers. This change might contribute to the conditions of traffic safety, which is a major concern for a modern society. Only in Europe, more than 30,000 fatalities and 1.6 million of other casualties occur every year in the road accidents. Older people drive less but still they are more likely to become a victim of the road crash. Also, due to the declination of health and physical conditions they are more fragile. Injuries that might not bring younger people to death can be fatal for elderly.

Safe driving requires good general level of physical and cognitive skills. Deterioration of these skills is the normal process, as people get older. However, it has a negative impact on the ability to operate a vehicle and to stay calm in difficult traffic situations. For older drivers, the majority of accidents result from making errors in complex road environments (Cerreli, 1989; Hakamies-Blomqvist, 1993; Zhang et al., 1998; McGwin & Brown, 1999; Davidse, 2000). These mistakes are associated with high level of stress that increases with the complexity of the road situation (Cantin, et al., 2009).

NHTSA reports that 16% of fatal and 21% of injury accidents in 2008 occurred due to the driver distraction (Ascone et al., 2009). One of these distracting factors is social pressure from other road users, represented by honking, tailgating, cutting off etc. The reaction of older drivers to honking vehicle is the following (Chen et al., 2013): "Being honked at may cause annoyance, stress, anger or panic that interferes with safe decision-making and driving. To mitigate this threat, drivers must minimise distracting negative emotions, focus on the road ahead, appraise the situation and respond safely" (p. 432). Therefore, social pressure that lead to increase of stress level together with the complex road environments represent the high risk factor for older drivers. As the population of elderly will only continue to increase, the problem of effect of social pressure on driving ability of older drivers becomes and important issue for the future of traffic safety. The goal of this research is to investigate the mentioned problem and to provide evidence for future studies and development of traffic safety policies.

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2. LITERATURE REVIEW

2.1 Driving ability of older drivers

2.1.1 The problem of a population aging

Drivers' age plays an important role on the driving ability. Older drivers are more subject to various cognitive and psychomotor problems than younger people. These problems affect not only their everyday life but also performance on the road.

The population of elderly drivers is experiencing a steady growth (Morgan & King, 1995; Aplin, 2009). The reason is so-called "baby-boom" generation born in the period from 1940s till 1960s. According to Aplin (2009), the percentage of older drivers will rise to 18.2% in 2025, and in 2050 it will reach 20.6% of driving population. The statistics of Centres for Disease Control and Prediction (2013) states that in 2009, in the United States of America the number of drivers aged sixty-five and older corresponded to 33 million people. In comparison with 1999, the population of elderly drivers had an increase of 23%.

For a modern society, mobility is an important life condition. Staying mobile is even more important for the older population. Morgan and King (1995) say, "driving is an important means of maintaining freedom and independence for older people. They are more likely to have disabilities restricting mobility and access to routine transport, so without their own cars they are limited and their quality of life is reduced" (p. 525). So, the research of driving-related issues of elderly drivers becomes important not only for theory, but also for deeper understanding of the problem in order to contribute to road safety.

2.1.2 Effect of aging on driving ability

"Older drivers are not so much a risk to others, but they are at risk themselves" (Safety Net, 2009). They do not constitute a big problem to the traffic safety in general, but because of their fragility they have more chances to be injured, even fatally, in case of road accident.

According to Meng (2010), elderly drivers are relatively safe group of drivers. She also mentioned factors, which led to the opposite idea of older drivers being more risky in road traffic. These are frailty and low mileage biases.

Frailty bias

As the age increases, drivers become more fragile: therefore, in accidents they are more often seriously or fatal injured than younger drivers (for the same conditions). The more serious the outcome of the accident, the bigger chance that it will be reported to the police. Therefore, registered accidents include larger part of old rather than young drivers and in this way the accident risk for becomes overestimated (Hakamies-Blomqvist, 1998).

Low mileage bias

Drivers, as they get older, try to reduce the amount of far trips and/or trips to not familiar areas. Therefore, their mileage reduces significantly (Safety Net, 2009). In comparison with more active drivers, who make use of highways more often, older drivers travel in close areas using the urban or rural roads. As the accident probability is always smaller on the highway, driving more on the urban or rural road becomes more risky for any driver, no matter how old he or she is (Hakamies-Blomqvist, 2003).

As a result, due to these biases the accident probability for older drivers often tends to be overestimated. So, this contributes to the previous statement made by Meng (2010) that older drivers are actually safer in the road traffic.

But does the aging constitute an impact for the traffic safety? To answer the question, it is first necessary to understand what driving is; which skills are necessary for driving and what effect does the age increase have on these skills.

According to McKnight (1999), driving requires three categories of skills: perception, attention and motor skills. Ability to perceive the road environment contributes to safe operation of a vehicle (for example, gap acceptance and identification of hazards and obstacles on the road). Attention, or ability to focus on a task, is needed to monitor the traffic situation ahead, behind and to the side of a vehicle. Finally, motor skills are needed to control the vehicle manoeuvrability (steering, braking etc.).

The Government Accountability Office in the United States (GAO, 2007) says that "driving is a complex task that depends on visual, cognitive and physical functions that enable a person to: see traffic and road conditions; recognize what is seen, process the information, and decide how to react; and physically act to control the vehicle" (p. 5). Therefore, driving ability depends of three factors:

- Cognitive function,
- Physical condition,
- Health condition.

The following question is whether mentioned conditions, required for driving, deteriorate with the increase in age. The following sections will consider the effect of age on each of these conditions in detail.

Cognitive deterioration

Cognitive impairment is "confusion or memory loss that is happening more often or is getting worse during the past 12 month" (U. S. Department of Health and Human Services, 2011, p. 2). As it follows from the definition, cognitive deterioration results in difficulties in learning, memorizing, concentration etc. There are two stages of the impairment: mild and severe. Mild stage is characterized by the disruptions of cognitive functions but without influence of everyday life. Severe stage can lead to disability of a person to live independently because of losing memory, ability to talk and write, not understanding of surrounding processes and making impaired judgments (Meng, 1995). The most often illnesses related to cognitive impairments are dementia and Alzheimer's diseases. This research is aimed at examination of cognitively healthy older drivers; therefore, the Mini Mental State Examination (MMSE) is used in order to identify whether the participants are subject to cognitive impairments (ANNEX 1).

Physical deterioration

Physical deterioration relates to declination of motor and visual skills. Similar to the cognitive impairment, this is the normal part of aging (Morgan & King, 1995). As people are getting older, their physical conditions are changing as well. Together with functional limitations it leads to high fatality rate among older drivers (Safety Net, 2009).

Declination of visual skills

Visual skills include different types of vision, such as dynamic vision, contrast sensitivity etc. The majority of these abilities change with an increase of age. Meyer (2004) completed a summary of types of visual skills together with the age-related change (increase/decrease) and implications for driving (TABLE 1).

TABLE 1: Age-related changes for various types of visual skills (Meyer, 2004)

Ability	**Major changes**	**Driving implications**
Visual acuity: Ability to resolve small details when viewed from a distance	Decline of visual acuity (myopia, near sightedness); can be partly corrected with lenses	Need for corrective lenses while driving
Dynamic visual acuity: Ability to correctly observe the direction and speed of a moving object	Decline in dynamic visual acuity	Difficulty in determining rate of approach and time to collision of moving objects
Focusing on near objects: Ability to resolve small details in a near object (farsightedness or presbyopia when related to age)	Difficulty in focusing on near objects due to the loss of elasticity in the lens of the eye; can be corrected with reading glasses or bifocal lenses	Need for-bifocal lenses or reading glasses to see in-vehicle displays or to locate smaller controls
Contrast sensitivity: Ability to detect changes in the lightness of a surface	Decline in contrast sensitivity	Difficulty in detecting objects or changes in the road that appear as changes in shading
Night vision: Ability to see in poor lighting conditions	Cataracts and senile miosis limit the amount of light that reaches the receptors	Difficulty in seeing objects in dim lighting (at night, in tunnels, or garages)
Disability glare resistance: Poor vision in glare conditions	Less luminance is required to produce disability glare	Difficulty in night driving and in changing levels of illumination
Recovery from glare: Time required to regain night vision after exposure to bright light	Increased susceptibility to glare and slower recovery from glare	Difficulty in night driving and driving in changing levels of illumination
Peripheral vision: Angular width of field of view in which motion information is perceived	Decrease in size of horizontal peripheral visual field	Late detection of events that develop in the periphery, such as approaching cars
Useful field of view: Width of visual field over which information can be acquired in a quick glance	Decline in spatial and peripheral vision	Difficulty in detecting events that develops at the sides of the visual field (merging cars, etc.)

TABLE 1 (continued)

Colour vision: Differential perception of light with different wavelengths	Loss of sensitivity to shorter wavelengths resulting in reduced ability to discriminate blues, greens and violets	Responses to color-coded displays may be affected
Visual scan: Speed and efficiency of movement of fixations in the visual field	Slowing of visual scan	Difficulty taking in complex traffic situations

Declination of motor skills

Aging is also a reason for the slowing of motor functions, which occur due to dysfunction of nervous and neuromuscular systems (Seidler et al., 2009). This declination results in loss of joints flexibility, deterioration of manual dexterity and muscular strength, which happens due to loss of muscles fibres (Morgan & King, 1995; Safety Net, 2009). These declinations then lead to difficulties in car operation and also contribute to increased fragility in crashes. Declination of joints flexibility differs for various parts of the body. In comparison with young people, elderly have 12% reduction of cervical flexion, 32% reduction in neck extension, 22% reduction of lateral flexion and 25% reduction of rotation (Kuhlman, 1993; Safety Net, 2009). The example of motor skills deterioration on the driving performance is the reduction of neck rotation. It restricts the driver's ability to check traffic at intersections (crossing) and on highways (merging). This is especially disturbing factor for older drivers, who tend to rely on neck rotation in order to compensate limited visual area (Safety Net, 2009).

2.1.3 Common crash types and fatality rates

Crash types

Numerous studies and questionnaires proved that the most common crash type for older drivers involves turning movements. In comparison with younger drivers, for those of 80 years and older, the crash percentage involving turning manoeuvre rises from 64% to 90% (Ryan, 1998). More specifically, high crash rates are common for making left turn at the non-signalised intersection against the oncoming traffic, which has the right of way (Cerreli, 1989; Hakamies-Blomqvist, 1993; Zhang et al., 1998; McGwin & Brown, 1999; Davidse, 2000). The driving behaviour at intersections requires high attention, concentration on multiple traffic elements and fast decision-making (Safety Net, 2009). Together with age-related health issues and deterioration of necessary skills, driving at intersection becomes difficult and dangerous task for older drivers. The complexity of intersections leads also to rear-end collisions at signalised intersections (Transportation Research Board, 1991).

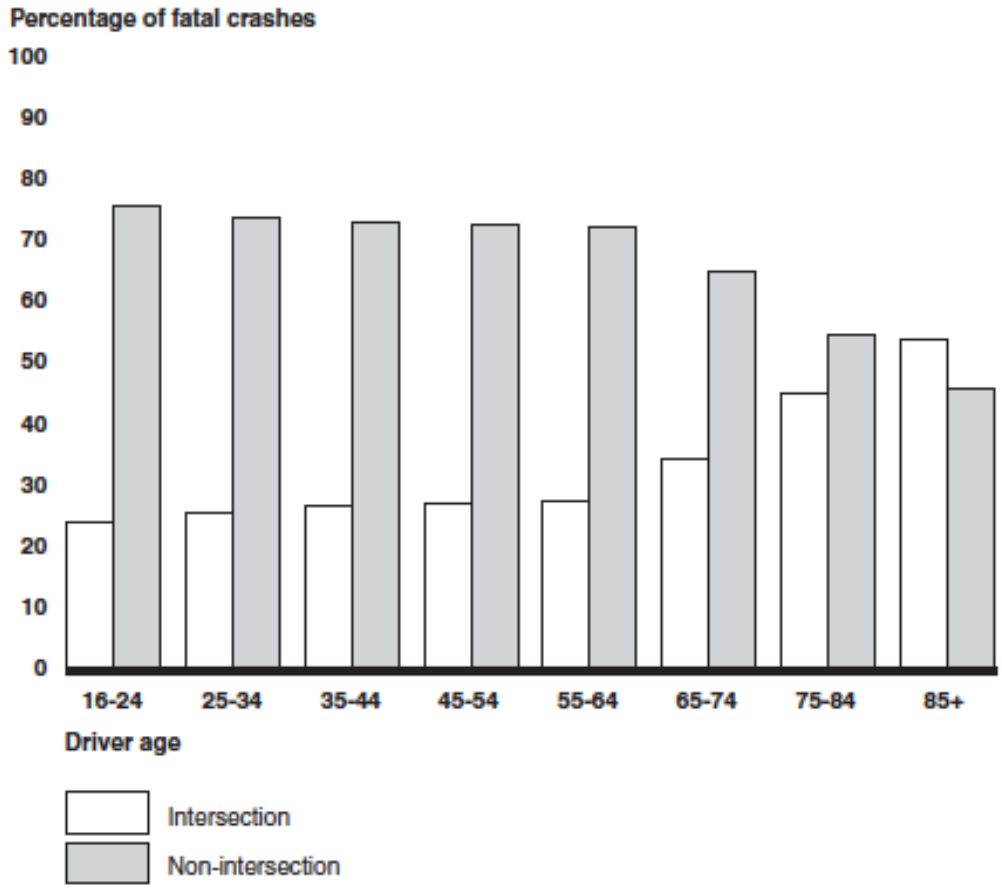
According to Safety Net (2009), there is another age-related crash type, which is wrong-way driving. These crashes represent approximately 1% of total number of accidents for all age groups. However, there is a considerable difference in crash occurrence according to age. Blokpoel and de Niet (2000) indicate that one third of wrong-way driving crash that led to serious accident or fatality involved drivers of 70 years and older. Staplin et al. (2001) found similar results in studies of Tamburri and Theobald (1965) and Lew (1971). They provided the same conclusion that drivers of 70 years old and more constitute the majority in wrong-way driving accident.

Often, self-reported analysis of crashes of older drivers refers to misjudgement of speed and distances to other vehicles (Cantin et al., 2009). Therefore, the presence of social pressure on the road (tailgater) can be a contributing factor to crash occurrence.

Fatality rates

Intersections are also road sections with the higher fatalities among older drivers. FIGURE 1 shows the percentage of fatal crashes per age of a driver at intersections and other locations (GAO, 2007). As age increases, the number of fatalities among drivers is almost doubled.

FIGURE 1: Fatal accidents at intersections by age of a driver (GAO, 2007)



In general, fatality rate for older drivers is relatively high. The reason for that might be either higher crash rate or fragility. According to Safety Net (2009), crash rate for age group 75+ is considerably higher that for all other ages.

2.2 What is stress?

2.2.1 Definition of stress

The modern society is close familiar with the word ”stress”. This word has such a firm place in our everyday dictionary that it becomes difficult to believe how young the concept of stress is.

The first person to introduce stress to the world was the Austrian-Canadian endocrinologist Hans Selye. His experiment in 1946, initially aimed at the discovery of a new hormone, led to unexpected results and gave a birth to the theory of stress. In 1956 he publishes the book “The Stress of Life” (Selye, 1956), which describes the findings of the research. In the *Journal of Clinical Endocrinology* Selye (1976) says: “I wrote *The Stress of Life* in the belief that because the general public was becoming keenly aware of the role played by stress in their own lives, they would like to understand just what stress is and what it does to us”.

So, what is stress? It has a variety of definitions and interpretations, the best one of which was given by Selye himself, “Everyone knows what stress is, but nobody really knows”. In 1992, researchers Jex, Beehr and Roberts analysed 51 journal articles, which were dealing with stress. The results identified four categories; according to them, the term “stress” was explained as the characteristic of:

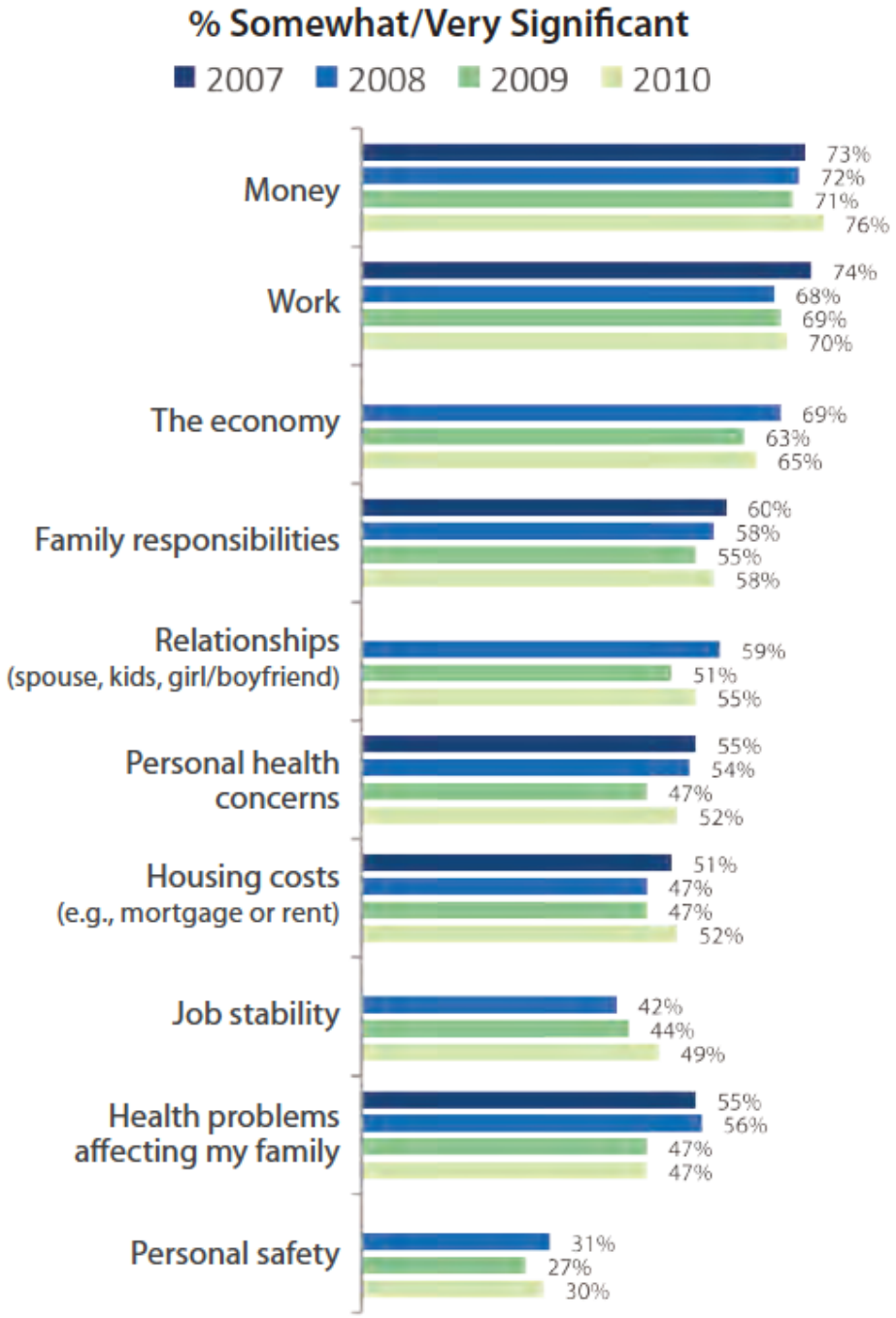
- Stimulus (41%),
- Both stimulus and response (25%),
- Response (22%),
- Undefined (14%).

For the convenience of this research, stress is considered to be a behavioural response of the human organism to the external pressure. The effect of stress on the behaviour is one of the points of interest for this study.

Stress reasons

For many people the cause of stress arises from the surrounding world and their position in it. This becomes clear from the survey, conducted by the American Psychological Association (2010) within the USA. The survey sample consists of 1,134 adult residents of USA and the Youth Query survey results from 1,136 young people from 8 to 17 years old. FIGURE 2 represents the findings of the survey.

FIGURE 2: Causes of Stress



BASE: All respondents 2007 (n=1848); 2008 (n=1791); 2009 (n=1568); 2010 (n=1134)

Q625 Below is a list of things people say cause stress in their lives. For each one, please indicate how significant a source of stress it is in your life.

The survey results show that top reasons come from the outside world, which means that they are external causes. On opposite to them, internal causes are produced within people's mind.

External causes relate to:

- Environment,
- Society,
- Life events,
- Everyday hassle.

Internal causes relate to:

- Lifestyle,
- Negative thinking,
- Attitude,
- Type of personality.

The fundamental distinction between external and internal stress causes is controllability: a person has no influence on external reasons but can have a full control over internal ones ("Daily Mail", n. d.).

The driving stress can be a result of both external and internal causes. Poor weather and road conditions, social pressure on the road represented by tailgaters are external stressors; internal stressors might be underestimation of driving skills, experiencing fear while driving, constant feeling of being guilty etc.

Stress stages

The external and internal stress reasons induce the protective reaction of the organism, i.e., stress response. According to Selye (1955), stress response is expressed in term of General Adaptation Syndrome (GAS) and consists of three stages: alarm, resistance and fatigue.

1. Alarm stage

The alarm stage is the first stage in the organism response process. It is characterised by the ejection of hormones (cortisol, adrenaline, noradrenaline). During this phase, the body activates the "fight-or-flight" system (Cannon, 1915) and is ready to resist the threat.

2. Resistance (adaptation) stage

This stage comes with the increase of stress duration. During the resistance phase, the body continues to produce hormones but not as much as on the alarm stage. The body still remains mobilized. However, the stress resistance is not that strong anymore.

4. Fatigue (exhaustion) stage

If the stress duration continues to increase even more, the organism comes to the fatigue stage. The resources of the body are exhausted and it is not able to resist. The result can lead to the disease or even death.

Stress effects

The definition states, that stress is the response of the organism to external or internal pressure. It means, that some changes are happening to different systems of the human body. These changes are classified into three categories, which are called effects of stress. They are: psychological effect, physiological effect and cognitive effect.

Professor Kitaev-Smyk in his book "Psychology of Stress. Psychological Anthropology of Stress" (1983) provides complete and comprehensive analysis of stress effects.

Psychological (emotional and behavioural) effect

The change in behaviour due to stress varies due to the type of personality. Friedman and Rosenman (1976) in their research regarding heart disease identified two types of personality according to the stress response: type A and type B.

Type A, or stress prone personality, is characterised as a type that cannot cope well with stress. People of this type are often aggressive, highly competitive and experience constant time urgency. They are trying to do several things at the same time and become impatient with any delay. Such kind of behaviour causes high level of stress for long period of time, thus leading to various stress-related health problems.

Type B (stress resistant) personality is the opposite of the type A. People of this type are more relaxed; also, they do not compete with time and thus experience less stress during the lifetime. The number of successful individuals, however, is lower than those of type A.

This classification is very general and includes only basic characteristics. There are still people, who fit neither into type A, nor into type B personality (McLeod, 2011). More detailed behavioural patterns belong to Selye (1956), for which he specified four stress response tendencies: fight, flight, tolerate and avoid. As it follows from the name, the "fight" response aims at the elimination of stress impact or its cause. On the other hand, people with "flight" response try to escape from the stress, physically and/or mentally. There is also a situation, when people cannot fight or flight, so they keep relatively calm; this can bring them to the state of not knowing what to do, so they "tolerate" the stress. Finally, "avoid" response is basically conflict avoidance and the possibility to think about the further steps.

The examples of psychological symptoms of stress include irritation, inability to relax, depression (emotional symptoms) and increase/decrease of appetite, increase/decrease of sleep duration and isolation from society (behavioural symptoms).

Physiological effect

As a response to the pressures from the outside world, the human body tends to protect itself and activates its additional sources. Therefore, stress hormones are released into the blood in big quantities: adrenaline, noradrenaline and cortisol (Klein, 2013).

Adrenaline (epinephrine) is a stress hormone, which is activated for the immediate response of the organism to the threat (Klein, 2013). It causes high heart and breathing rate, increase blood pressure and sweating, increase of focus and concentration.

Noradrenaline (norepinephrine) is basically the same stress hormone as adrenaline. It is also a hormone that is activated as an immediate response of the organism. Like an adrenaline, it causes the heart rate to rise and increases the breathing rate. However, there is a small difference between these hormones on cellular level, which has an effect of their functions. (Siribaddana, 2010).

Cortisol is a stress hormone that manages effects of adrenaline and noradrenaline. On the contrary to the other two stress hormones, cortisol needs more time to be released (Silbernagl & Despopoulos, 2008).

The examples of physiological symptoms of stress include pain, dizziness, increased rate of heartbeat and frequents colds.

Cognitive effect

Cognitive functions tend to decline with an age. But these people, who are also experiencing high levels of stress during their life are under bigger impact. Stress affects the brain function but there is a difference in the cognitive effect of short-term and long-term stress.

Short-term stress is characterised by an increased level of adrenaline and noradrenaline. These hormones help the organism to better concentrate and keep it focused. Therefore, this kind of stress can have a positive effect on the cognition.

While experiencing the long-term stress, there is a high level of stress hormone cortisol in the organism. This can have a negative impact on the cognitive functions, such as memory and learning ability.

Recent study in Buenos Aires University (Reich, 2011) investigated the connection between long-term stress and development of Alzheimer disease and dementia as its symptom. During the research, 98 patients were studied, among them people impaired by or with probable Alzheimer disease, with an average age of 73 years. The study was looking for the major stressful events that happened three years before the Alzheimer's diagnosis. The results indicated that 73% of patients had a major stress episode on average 2 years before the appearance of dementia.

Keinan and Friedland (1984) investigated the influence of stress on the learning ability. They concluded, that high stress level during the study process disrupt the learning ability. The same results were obtained from the similar researches (Thompson, Williams, L'Esperance & Cornelius, 2001), which investigated learning abilities in the skydiving conditions. Therefore, the contradiction arises between the results of the study and the commonly accepted idea that learning in realistic conditions contributes to better performance (Staal, 2004).

The examples of cognitive symptoms of stress include problems with memory, worrying, pessimism, poor concentration and judgement.

2.2.2 Stress and performance

First studies of the relationship between stress and performance go back to the beginning of the twentieth century. At that time, the definition of stress as it is known now did not exist yet. Instead, scientists used the term "arousal", which is more general term. According to Razmjou (1996), "arousal is a hypothetical construct that represents the level of central nervous system activity along a behavioural continuum ranging from sleep to alertness" (p. 530). This term is considered to be a stress response regulator. It also covers psychophysiological, behavioural and cognitive areas. Therefore, arousal is used as a synonym to stress.

In 1908, *Journal of Comparative Neurology of Psychology* published the article "The relation of strength of stimulus to rapidity of habit-information" about the experiment of two scientists, Yerkes and Dodson (1908). This was the first experiment that investigated how a stress factor influences the performance. It was a laboratory experiment on mice. Animals were put in the box with two doors, black and white. Selection of a white door to leave the box was a correct solution. Otherwise, if mice chose black door, they were given an electrical charge (considered as a stress factor) to learn that this choice is wrong.

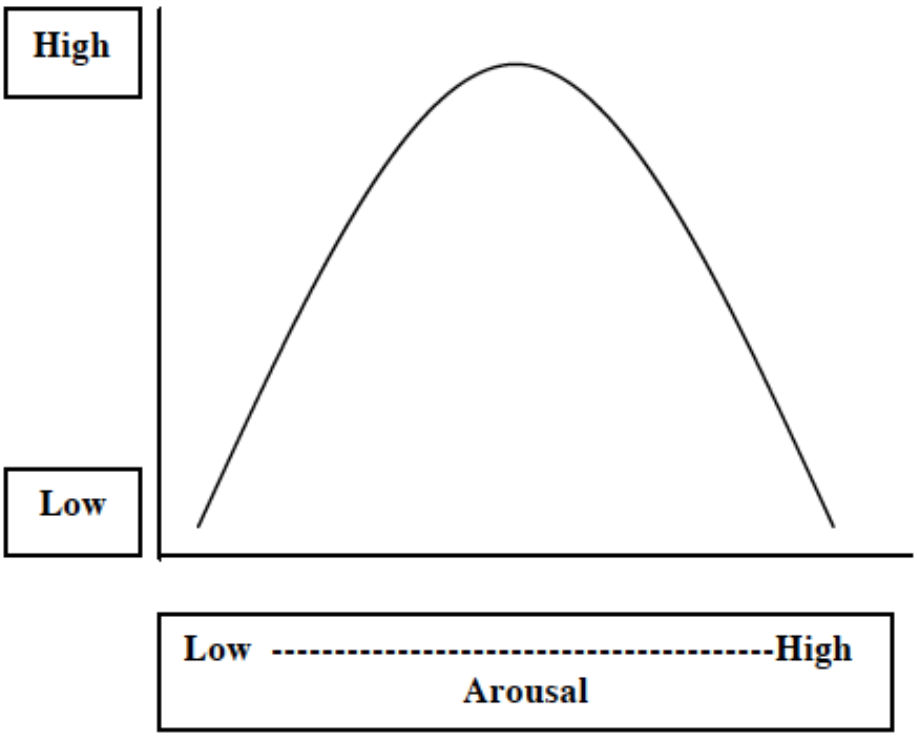
The result of the experiment pointed several important conclusions. Among them, Yerkes and Dodson (1908) stated, "the rapidity of learning increases as the strength of the electrical stimulus is increased from the threshold of stimulation to the point of

harmful intensity" (p. 481). Also, the results showed that higher intensity of the electrical shock contributed to faster learning than that one of low intensity.

The conclusions of experiment were generalised into Yerkes-Dodson principle, which later developed into Yerkes-Dodson law of performance.

The Yerkes-Dodson law (FIGURE 3) is also known as inverted-U curve. It describes the relationships between the level of stress and performance. Vertical axis corresponds to performance level (from low to high), the horizontal axis represent the level of arousal (or stress), from low to high. The shape of this dependency shows that as the level of stress increases, the performance improves as well. However, it rises till the certain point (point of the best performance and optimal stress). With the further increase of the stress level, the performance after its maximum point will start to decrease (Staal, 2004).

FIGURE 3: Yerkes-Dodson performance law



A workload level has an impact on driving performance also. Lack of information the same as information overload may be a reason for driving mistakes. Lack of information (FIGURE 4) can decrease driver's attention. This gives false feeling of awareness and therefore some drivers might react to this by increasing their speed. On the other hand, the overload of information (FIGURE 5) dissipates the attention of a driver and more time is needed to identify primarily important information (Kocourek & Padelek, 2011).

FIGURE 4: Information underload

FIGURE 5: Information overload

Regarding high workload induced by exces of information, Paul Stenquist (2013) in his article in *New York Times* says "the overload of inputs, perhaps amplified by foul weather or a demanding toddler, presents a real challenge to the driver – and a danger to all road users". On the other hand, small workload has its problems too (Vanderbilt, 2008), as drivers get tired and start to make mistakes.

According to Aust et al., (2011), Yerkes-Dodson law also comes in force when the traffic situation becomes difficult and negotiations with other drivers are necessary (tailgating, honking). The negotiation here plays a role of external stressor inducing the driver's arousal, which first up to some limit will improve performance, and if continues to increase, will have a negative impact on driving ability.

For older drivers, high workload in combination with difficult driving situations (for example, intersections) can result in errors and mistakes. In comparison with young drivers, the workload of older drivers increases disproportionally with the increase of driving complexity (Cantin, et al., 2009). Given the same level of additional workload, the attention management capabilities of older drivers are lower than of younger ones (Rogers & Fisk, 2001).

2.3 Stress effect on driving ability of older drivers

Stress significantly influences driving performance. As it was mentioned in a previous chapter, optimal level of stress can have a positive impact and maintain driver's attention and concentration on the road. Higher levels of stress, however, can result in poor performance, violations and increase of crash risk (Beirness, 1993).

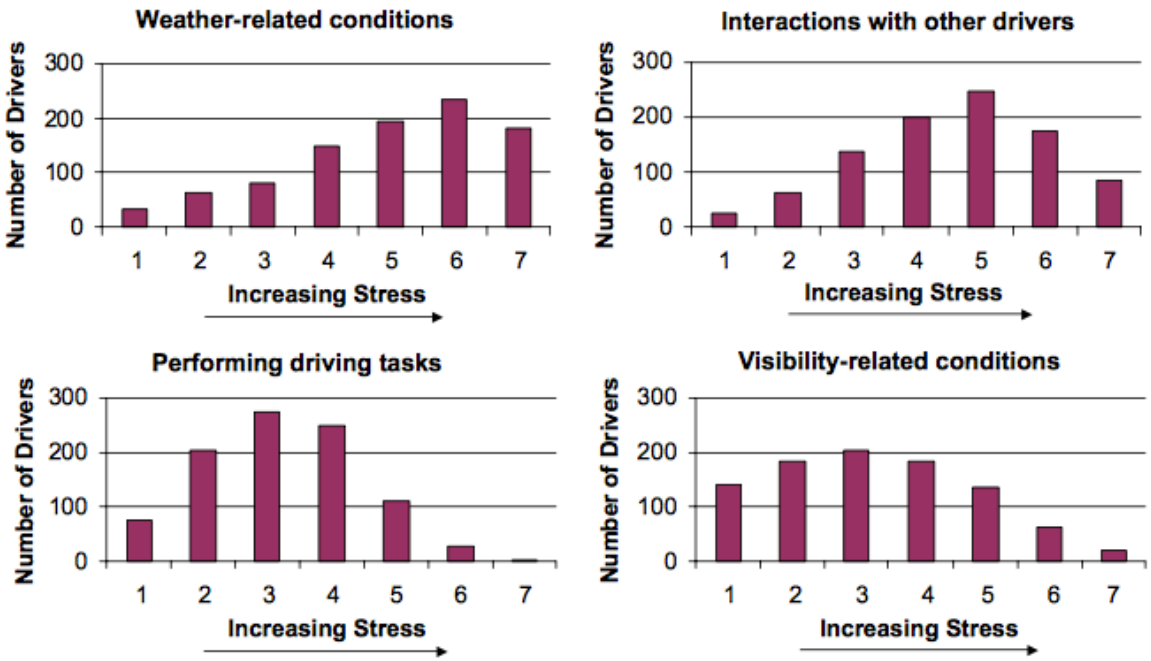
2.3.1 Age and gender differences in stress arousal

Gender and age of a driver also play an important role on the behavioural and psychological aspect of stress. Generally, women experience higher stress while driving (Westerman & Haigney, 2000). In terms of age, older drivers are subject to higher levels of stress on the road (Westerman & Haigney, 2000). This becomes also one of the reasons for elderly to stop driving (Keall & Frith, 2004). Westerman and Haigney (2000) state that younger drivers release driving stress in a form of aggression, while older drivers experience situation-specific tension.

2.3.2 Stress factors in driving

There are also other factors that induce stress for drivers. These are environmental conditions, visibility, interactions between drivers etc. Hill and Boyle (2006) conducted a survey-based study, where they asked participants to assess their stress level for different influential factors on the 7-point scale (1 – not stressful to 7 – very stressful). The results of this research are presented on FIGURE 6.

FIGURE 6: Average level of stress distribution per influential factor



For weather-related conditions, the highest level of stress corresponded to (from most stressful to least stressful):

- Non-freeway icy roads,
- Freeway icy roads,
- Non-freeway roads with heavy rain or snow,
- Freeway roads with heavy rain or snow.

For driver-driver interactions (from most stressful to least stressful):

- Front vehicle moving slower than the speed limit (non-freeway road),
- Front vehicle moving slower than the speed limit (freeway road),
- Front vehicle braking constantly (non-freeway road),
- Front vehicle braking constantly (freeway road).

For driving task conditions (from most stressful to least stressful):

- Left turn against oncoming traffic (non-freeway uncontrolled intersection),
- Passing through non-freeway uncontrolled intersections,
- Crossing lane to exit (freeway),
- Right turn on another road (non-freeway),
- Merging into heavy traffic (freeway),
- Mountain roads (non-freeway).

For visibility-related conditions (from most stressful to least stressful):

- Night freeway driving,
- Night non-freeway driving,
- Driving next to the truck (freeway),
- Driving next to the truck (non-freeway).

2.3.3 Social pressure as a stress factor in driving

NHTSA reports that 16% of fatal and 21% of injury accidents in 2008 occurred due to the driver distraction (Ascone et al., 2009), which can be visual, auditory, biomechanical and cognitive (Ranney et el., 2000). Social pressure is also a form of distractor and might relate to both visual and cognitive factors.

Social pressure from drivers and their behaviour in traffic (tailgating, cutting off, chasing, breaking in front of the car etc.) causes stress for other road users. This kind of pressure can be unintentional; often, however, this is an intended aggression against other road users. According to James (1997), social pressure is the result of modern driving experience, which is full of stress, anger and fear. It is also exacerbated by the

growing level of traffic congestions that stimulates the aggressive and retaliate behaviours (Connell & Joint, 1996).

Aggressive driving has an increasing tendency (Altman, 1997; James, 1998). According to age and gender, the most aggressive drivers are men 18 to 26 years old (American Automobile Association, 1997). Deffenbacher, Oetting and Lynch (1994), however, stated that young men and women have equal aggressive attitudes while driving.

According to James (2000), the aggressiveness on the road is correlated with the following driving behaviours:

1. *Experiencing more stress*
2. Swearing
3. Acting in a hostile manner
4. Regular speeding
5. Regular fighting with other drivers
6. Honking
7. Making insulting gestures
8. *Tailgating*
9. Cutting off
10. Road rage behaviour
11. Feeling enraged
12. Violent fantasies
13. Feeling competitive
14. Rushing
15. Desiring to drive dangerously
16. Feeling less calm while driving

Leon James (2000) also says "these 16 driving behaviours define the aggressive driver syndrome. They are all significantly intercorrelated. This means that if you do one of them regularly, you will also do the other 15 on a regular basis".

Age of a driver is another decisive factor noticed in aggressive driving (Arnett, 1994; Puente & Castaneda, 1997). However, there are some inconsistencies regarding relation of younger drivers to elderly. Researches in the United States showed opposite results: some studies proved the negative attitude toward older drivers (Ryan, 1992); others concluded positive and/or neutral attitudes to elderly (Kogan, 1979; Kite & Johnson, 1986).

Nevertheless, traffic participants represent one group of road users; therefore they will try to adapt their behaviour to the behaviour in the group. This phenomenon is called *conformity.* According to McLeod (2007), conformity is "a type of social influence involving a change in belief or behaviour in order to fit in with a group". For traffic

conditions, non-conformity in most cases is not tolerated. Dr. James (1998) gives the following example of conformity in driving: “We don't want to start a war on the road, with regulars on one side and non-conformists on the other. Perhaps it's true, as some traffic engineers argue, that the speed of a convoy is not as dangerous as what the pack members do when getting around a slower moving vehicle that travels at "mere" speed limit. This means that if you're traveling in a convoy above the speed limit, as we almost always are, it's better to conform to the going speed than to attempt to hold things back by slowing down. Engineers say that the most dangerous element is the change in rate, caused by lane hopping and rubbernecking”.

In the research of older drivers’ reaction to honking vehicle as a social pressure on the road, Chen and colleagues (2013) say: “Being honked at may cause annoyance, stress, anger or panic that interferes with safe decision-making and driving. To mitigate this threat, drivers must minimise distracting negative emotions, focus on the road ahead, appraise the situation and respond safely” (p. 432).

Tailgating

Tailgating is a traffic safety problem, resulting in the following car moving too close to the rear end of the car in front (Keegan, 2010). Therefore, tailgaters reduce their distance necessary for a safe stop. This is a major cause of rear-end crashes and a contributing factor to fatal outcomes (Carter et al., 1995). According to Minnesota Department of Transportation, in 2005 tailgating became the reason for more than 28% of rear-end crashes and over 4% of fatal crashes in Minnesota. Traffic Management Director for Highways Agency says, “14% of casualties on our roads are caused by people tailgating. That is why we are reminding people to stay safe and keep at least a two-second gap from the car in front” (Highways Agency, 2014).

The USA National Survey among 1,200 adult licensed drivers conducted in March 2000 (Survey website) investigated the effect of age, gender and type of car driven in the United States. It also included questions about aggressive driving. According to results, 84% of people considered tailgating as the most dangerous act on the road; 95% of drivers used the term ‘tailgating’ to define the aggressive driving. TABLE 2 shows dangerous tailgating percentage according to age and type of car (James, 2000).

TABLE 2: Dangerous tailgating for age and type of car

	Family cars	Sport cars	SUVs
Young drivers (15 to 24)	9%	28%	21%
Middle aged drivers (25 to 54)	13%	13%	23%

Reasons for tailgating

Reasons for tailgating can be different. Sometimes, it can be caused by the front car, so-called "victim type" driver, who drives intentionally slow in a queue and therefore creates the frustration and stress for drivers behind. Ignorant tailgaters do not often realise they create dangerous situation because they are not concerned about other road users and situation on the road. Momentary tailgaters are usually heavy vehicles that try to keep gained speed behind slower road user. Normally, they return to safe position as soon as the traffic speed is restored. Impatient drivers always need to be ahead of other vehicles and they express this urgency in a tailgating. Not giving a way to this type of tailgater can make him aggressive. For an aggressive tailgater, the situation becomes personal offence, so he starts to intimidate the front vehicle and, therefore, creates even more danger on the road (Safe Speed campaign, 2007).

2.4 Research questions and hypothesis

The research questions are formulated as following:

- What is the effect of social pressure on driving performance of older drivers?
- Is there a relation between the subjective and objective effect of social pressure on driving performance of older drivers

The hypothesis of this research is the following:

- An increase of driver's age lead to poor response to social pressure during driving.

3. EXPERIMENTAL DESIGN

3.1 Method

The goal of this research is the investigation of driving behaviour of older drivers in the conditions of social pressure of the road, which is represented by tailgater. The following driving measures are investigated: crashes, complete stop at the stop sign (CS), driving speed, gap acceptance, priority giving and standard deviation of lateral position (SDLP).

These data is accompanied with the personal questionnaires, which include information about age, driving experience, effect of car behind and effort scale during the experiment, and Mini-Mental State Examination (MMSE). Participants were asked to share their opinion concerning their driving performance while completion of the driving task. Together with the data from driving simulator, it provides subjective and objective evaluations of the driving performance of participants.

This research incorporated different tasks and tests that help to assess driving behaviour of elderly drivers (with and without social pressure on the road) and their cognitive abilities.

3.1.1 Participants

In total, 143 people volunteered to participate in the research. However, due to simulator sickness the data was collected from 98 participants. All of them are active drivers with good health state, not stroke during last six months and not cognitively impaired (MMSE score 25 and more). The age of participants is 65 and more years old.

3.1.2 Driving simulator

The main tool for the data collection was the driving simulator of the Transportation Research Institute (IMOB), University of Hasselt (FIGURE 7). This is a fixed-based driving simulator operating on STISIM software (STISIM Drive website). This simulator gives the possibility to investigate the following parameters: speed of a vehicle, lane position, complete stop at a stop sign, detection of hazard and reaction etc.

FIGURE 7: IMOB driving simulator

3.1.3 Scenario

The scenario for the driving simulator was composed of two sub-tasks: first, participants drove in normal traffic conditions, which implied the absence of social pressure, and afterwards they followed similar scenario but together with presence of tailgaters behind their car, which were changing as the task progressed. Order of these scenarios was counterbalanced between subjects.

The total distance for each of scenarios corresponded to 6.6 kilometres; participants were driving in the inner city centre area, therefore had to experience multiple distractions and elements to pay attention to, for example, pedestrians, cyclists, traffic lights, crossing vehicles, change of speed limits etc. The task was mainly "going straight" along the road, and one time during the drive it was announced to complete the left turn at the intersection. In order to reduce the risk of simulator sickness, instead of completion of a left turn participants indicated the move by pressing the horn. Also, participants had a choice between use of manual or automatic gear on the driving simulator. Scenario with tailgater was the same as scenario without one. In total, 6 tailgaters were present, changing every 1000 meters, when there was no event on the road. Therefore, in case of event, tailgater was already present behind the respondent's car. If the driver deviated to the side, the tailgater followed in the same manner; this was noticeable via the rear mirror. Rapid braking/stop while driving led to the crash with the tailgater.

3.1.4 Cognitive measures

Mini-Mental State Examination (MMSE)

Mini Mental State Examination (MMSE) is used in order to identify whether the participants are subject to cognitive impairments (ANNEX 2).

MMSE test first appeared in the *Journal of Psychiatric Research*, introduced by Marshal F. Folstein and Susan E. Folstein (1975). This test checks the presence of mild stage of cognitive impairment by examining a variety of mental abilities. There are three versions of the test:

- Standard version, including 30 questions (this version is also used in the current research),
- Brief version, including 16 questions,
- Expanded version including 90 questions.

The interpretation of the resulting scores depends on two factors, which are age and the level of education. Based on these parameters, Crum et al. (1993) developed a set of norms representing the normal scores (TABLE 3).

TABLE 3: Median MMSE scores by age and educational level in a community sample (Crum et al., 1993)

	Education (years)				
Age (years)	0 to 4	5 to 8	9 to 12	>12	**n**
18-24	23	28	29	30	2,220
25-29	25	27	29	30	2,076
30-34	26	26	29	30	1,926
35-39	24	27	29	30	1,443
40-44	23	27	29	30	979
45-49	23	27	29	30	831
50-54	22	27	29	30	870
55-59	22	27	29	29	1,013
60-64	22	27	28	29	1,294
65-69	22	27	28	29	1,931
70-74	21	26	27	28	1,045
75-79	21	26	27	28	1,045
80-84	19	25	26	28	605
≥ 85	20	24	26	28	346

Note. N = 18,056.

The participants of current research are car drivers of 65 and more years old. According to the table, the average score for this category of drivers taking into account the level of education is 25,3. The inclusion criteria of the MMSE test for this research corresponds to 25 scores and more, which means that participants are not subject to cognitive impairments.

3.1.5 Subjective driving performance measures

NASA Task Load Index (TLX) questionnaire

NASA TLX questionnaire is a tool for a subjective assessment of participant's workload. It includes six subscales: mental demands, psychical demands, temporal demands, own

performance, effort and frustration (ANNEX 2), where higher scores reflect more efforts demand from the participant (NASA TLX website).

3.2 Data analysis

The SPSS was the main tool for the data analysis.

The experiment results showed, that six participants did not notice the tailgater. As they represent small part of the sample (6,1% of the total number), these participants were excluded from the further analysis. Therefore, the sample reduced from 98 to 92 participants.

Initially, the outlier analysis was done. The values exceeding three standard deviations range were treated to fit the range (Wood et al., 2008). Among detected outliers the following indicators were presented: age, number of crashes, driving speed, gap acceptance, MMSE and SDLP.

Descriptive statistics was used to examine the age, effect of car behind and MMSE scores. Paired-samples T test was applied to evaluate subjective effort assessment (based on NASA TLX scores).

The following step was the effect analysis. It included six driving measures: crashes, complete stop at the stop sign, driving speed, gap acceptance, priority and SDLP, for which repeated measures analysis of variance (ANCOVA) was conducted. The within-subject variable was scenario (1. driving with no tailgaiter, 2. driving with a tailgaiter; a covariate was a centred age of a respondent. For all tests, only F-values and probabilities are reported, with alpha level of 0,05. Based on the effect significance, the driving measures for the further analysis were selected. The identification of the effect size of scenario was done by calculating Cohen's d value, where the effect of an intervention is small at d<=0,2, medium, when 0,2<d<0,5 and large, when d>=0,5 (Magnusson, 2014). To investigate the effect of age, bivariate correlation for average of driving measure and age was done (Pearson 2-tailed). For an interaction measure, the effects of scenario and age were investigated separately. For an effect of scenario, ANOVA was applied based on median split to divide participants into age groups. Within-subject variables were driving measures with and without car; no covariate was used. For an age effect, univariate analysis of variance (ANOVA) was conducted with car and without car as dependent variable and age group as a fixed factor.

3.3 Results

3.3.1 Participants

The total number of participants corresponds to 92; the age ranges from 63 till 90 years old, with mean of 72,51 (SD=5,76). All of them are active drivers with good health state, not stroke during last six months and not cognitively impaired. MMSE score is 25 and more, with mean of 28,73 (SD=1,21).

3.3.2 Objective driving performance

The results of the repeated measures analysis for driving measures are represented in the TABLE 4 and 5. Among total number of driving measures, the significant effects are observed for three of them: driving speed (scenario), number of crashes (scenario, scenario x age and age) and priority (age).

TABLE 4: F and probability values for the driving measures per indicator

Driving measure	F	p
Crashes		
Scenario	10,988	**0,001*** **
Scenario x age	5,116	**0,026***
Age	7,437	**0,008****
CS		
Scenario	1,251	0,266
Scenario x age	2,225	0,139
Age	0,127	0,722
Driving speed		
Scenario	5,316	**0,023***
Scenario x age	2,965	0,088
Age	0,479	0,49
Gap acceptance		
Scenario	2,887	0,094
Scenario x age	0,131	0,719
Age	0,291	0,591
Priority		
Scenario	2,301	0,133
Scenario x age	0,435	0,511
Age	9,121	**0,003****
SDLP		
Scenario	0,537	0,466
Scenario x age	0,158	0,692
Age	0,004	0,95
*<.05, **<.01, ***<.001		

TABLE 5: Means and standard errors for driving measures without/ with the tailgater

Driving measure	Mean (SE) no car	Mean (SE) car
Crashes	0,446 (0,067)	0,837 (0,100)
CS	0,636 (0,040)	0,592 (0,040)
Driving speed	41,4 (0,649)	42,535 (0,556)
Gap acceptance	5,896 (0,172)	6,127 (0,156)
Priority	0,761 (0,030)	0,701 (0,034)
SDLP	0,185 (0,005)	0,189 (0,006)

Driving speed

For the driving speed, there is significant main effect of scenario. The speed variations do not depend on the respondent's age, but on the presence of the car (tailgater) behind their vehicle. The means for the driving speed without and with a tailgater are equal to 41,4 and 42,535 km/h correspondingly. The Cohen's d is used to specify the effect size of these two values. An effect size of Cohen's d=1.8.

Priority

For the priority, there is significant main effect of age. The results of the correlation between average priority and age resulted in r=-0,303 with a p=0,003.

The Pearson r=-0,303 indicates the medium negative linear relationships between two variables; it means, that as the respondent's age increase, it leads to less priority giving while driving.

Crashes

For crashes, there is a significant interaction between scenario and respondent's age. To investigate the effect of scenario, respondents were divided into two age groups (age median=71,5 years): group 0 includes 51 "young-old" drivers <=71,5 years, group 1 includes 41 "old-old" drivers >71,5 years. The results of repeated measures analysis are represented on TABLE 6.

TABLE 6: Main effect of scenario on the number of crashes

	F	p	Mean (SE) no car	Mean (SE) car
Age group 0	1,749	0,192	0,412 (0,089)	0,588 (0,105)
Age group 1	9,986	**0,003****	0,488 (0,100)	1,146 (0,183)

*<.05, **<.01, ***<.001

The crash number significance relate only to age "oldest-old". For driving condition without tailgater the mean crash numbers are similar for both groups (0,412 and 0,488

for group “young-old” and “oldest-old” correspondingly). With the presence of tailgater, however, the number of crashes grows for both groups. For “oldest-old” group, the crash mean changes from 0,488 to 1,146,. Thus, the age increase has an obvious influence on crash number, as older group experienced more crashes than younger group.

The univariate analysis was used to investigate the main effect of age on the number of crashes. The results of the analysis are shown on TABLE 7.

TABLE 7: Main effect of age on the number of crashes

	F	p	Mean (SE) group 0	Mean (SE) group 1
Scenario “no car”	0,323	0,571	0,412 (0,089)	0,488 (0,100)
Scenario “car”	7,633	**0,007****	0,588 (0,135)	1,146 (0,150)

*<.05, **<.01, ***<.001

The crash number significance relate only to scenario “car”, where the tailgater is present on the road. Therefore, the presence of tailgater leads to increased amount of crashes.

3.3.3 Subjective driving performance

Effect of car behind

This measure included two options for respondents: 1, if the tailgaiter had no influence on driving ability of driver and 2, if tailgaiter had an influence on driving ability of driver. According to reported data, 71,7% of total respondents had this influence, and 28,3% did not. Among comments concerning type of influence, participants mentioned that they:

- Experienced negative feelings as stress, pressure, fear or annoyance (7 comments);
- Avoided hard/sudden braking (3 comments);
- Started to drive faster (2 comments);
- Avoided collision or swerved to give a way (2 comments);
- Stopped late at red traffic light;
- Drove through orange traffic light;
- Started honking.

Effort scale

The results of paired-samples T test for subjective efforts assessment are shown on the TABLE 8.

TABLE 8: Paired samples t-test values

		t	p	Mean (SE) no car	Mean (SE) car
Q1 no car & car	Mental efforts	-0,757	0,451	3,52 (0,140)	3,6 (0,145)
Q2 no car & car	Physical efforts	-0,420	0,676	3,18 (0,143)	3,23 (0,147)
Q3 no car & car	Task progress (speed)	-1,432	0,156	2,95 (0,122)	3,11 (0,116)
Q4 no car & car	Task efforts	-0,162	0,871	3,36 (0,134)	3,38 (0,149)
Q5 no car & car	Insecurity	-0,946	0,347	3,2 (0,138)	3,32 (0,147)
Q6 no car & car	Stress	-1,470	0,145	3,03 (0,151)	3,21 (0,153)
Q7 no car & car	Boringness	0,274	0,785	2,74 (0,137)	2,71 (0,142)

*<.05, **<.01, ***<.001

Despite the fact, that the efforts changes do not have significant effect, for all categories there is a clear increase of values at the presence of tailgater (except for the question 7 “boringness”, where the decrease means less boring situation with a tailgater). On one hand, it supports the respondents reported effect of car behind, and on the other hand, it might be an indication, that respondents who reported no influence from tailgater, still had one.

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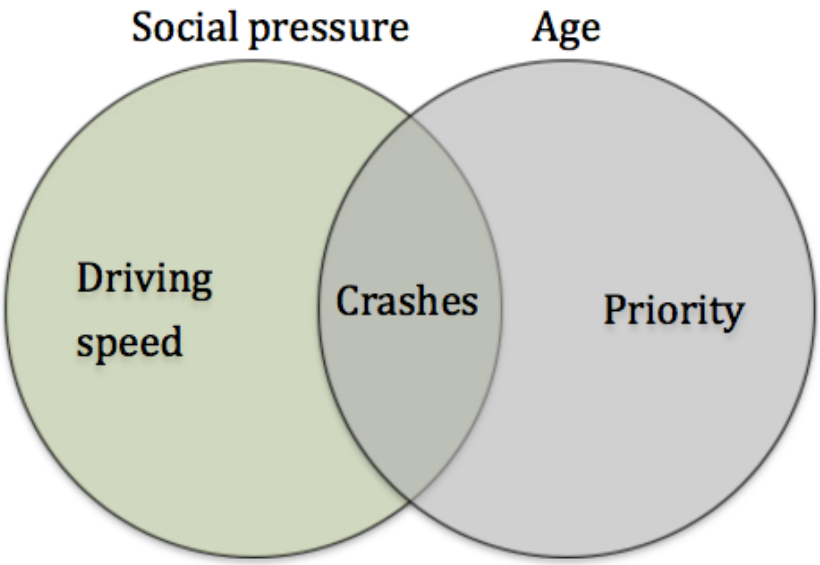
4. DISCUSSION

The purpose of this research was to investigate the effect of social pressure on the driving ability of older drivers. Additional evaluation was conducted to compare the subjective and objective driving performance.

Three out of six investigated driving measures had a significant effect related to social pressure and/or age (FIGURE 17).

FIGURE 8: Significant effect of scenario and age on the driving measures



Driving measures

The effect significance for the **driving speed** related only to the scenario. Therefore, the presence of tailgater was the only factor influencing the increase of a mean speed of the car. While the reasons for tailgating can vary, major drivers perceive it as an aggressive driving behaviour (USA National Survey, 2000), resulting in additional distraction and stress (Ascone et al., 2009). One of these reasons is low speed of the front vehicle (Safe Speed Campaign, 2007). This is also observed in this research, when respondents drive on average 41,4 km/hour at speed limit of 50 km/hour without tailgater. As own speed selection is influenced by the perceptions of the speed of other vehicles (Hagland & Aberg, 2000), tailgating can initiate the speed increase of front vehicle, which will tend to conform to the traffic situation (McLeod, 2007). Acting as additional stressor, tailgater can be the reason of negative feelings for the front driver (anger, panic, annoyance), therefore interfering safe driving and decision making. Similar conclusion was also done in the study of older drivers' reaction to honking vehicle (Chen et al., 2013). In this case, increase of speed can be explained by the wish of a driver to increase safe distance between two vehicles or to escape from the follower.

The effect significance for **priority** related only to the respondent's age. Medium negative linear relationships between two variables indicated that giving less priority while driving is associated with an increase of the driver's age. For both cases, with and without social pressure, the older group of drivers (71,5 to 90 years) had worse performance than the younger group. This result is associated with the age-related deteriorations of psychophysiological skills enforced by the combination of complex road situation and additional stress. Change of vision of elderly causes declinations of visual acuity, focus, spatial and peripheral vision, which in its turn can lead to tunnel vision (Morgan & King, 1995; Meyer, 2004). Therefore, the driver does not notice approaching car, especially if obstacles are present on the roadside. Another reason for priority rules violation is deterioration of motor skills occurring due to dysfunction of nervous and neuromuscular systems (Seidler et al., 2009). Loss of joints flexibility, muscular strength and manual dexterity cause difficulties in traffic observations and fast response to dangerous situations, and also cannot compensate narrow visual area (Morgan & King, 1995; Safety Net, 2009). This explains high crash rates in complex traffic situation, where physical limitations affect multitasking and safe decision making, and information excess creates additional workload leading to driving mistakes and errors (Transportation Research Board, 1991; Safety Net, 2009).

The majority of crashes involving older drivers result from their failure to give priority while turning at non-signalised intersections against oncoming traffic, which has the right of way (Cerreli, 1989; Hakamies-Blomqvist, 1993; Zhang et al., 1998; McGwin & Brown, 1999; Davidse, 2000). Also, older drivers report misjudgements of speed and distances to other vehicles, which can be one of the contributory factors in priority violation (Cantin et al., 2009). This statement relates to the number of crashes, too.

For **crashes**, there is a significant interaction between the social pressure and respondent's age. The older group of respondents experienced much larger increase in number of accidents while driving under social pressure than younger group. Tailgating is a growing problem worldwide and also a reason for many rear-end and fatal crashes (Altman, 1997; James, 1998; Minnesota Department of Transportation, 2005; Ascone et al., 2009; Highway Agency, 2014). Most of drivers define tailgating as aggressive driving behaviour (USA National Survey, 2000); it also plays a role of distractor and stressor to other road participants, creating potentially dangerous situations, in particular, for the older drivers. Elderly have higher stress levels and tend to experience situation-specific tension (Westerman & Haigney, 2000), especially while negotiations with other drivers (Hill & Boyle, 2006). Therefore, tailgating becomes a cause for crashes for older drivers due to their 1) age-related skills limitations, 2) age-related increase of stress level, and 3) situation-specific increase of stress level, resulting from combination of negotiations with other drivers and complex traffic situation.

Subjective and objective performance evaluation

The results of objective driving evaluation showed the deterioration of performance in the scenario with the tailgater. Also, all respondents noticed the tailgater and majority of them (71,7%) reported that somehow they were influenced by the tailgater: experiencing more negative feelings, avoiding fast and rapid braking, increasing speed etc. (Chen et al., 2013). Subjectively, however, respondents evaluated their performance with quite high scores. Despite the slight increase in efforts' means for the scenario with tailgater, these changes are not significant. Therefore, the subjective performance evaluation, even with reported influence from tailgater, still remains overestimated (Cuenen et al., 2015).

4.1 Limitations

Simulator sickness

Simulator (motion) sickness, which is a set of symptoms caused by exposure to illusory motion (Stern & Koch, 1996), represent a major limitation in driving simulator research with older drivers. It results in sweating, repeated swallowing, vomiting etc. (Edwards et al., 2003). In this research, the simulator sickness resulted in significant decrease of sample. Initial number of participants corresponded to 142 and in the end only 92 remained (decrease of 35%). This number is similar to other research (Edwards et al., 2003), with the 40% of participants decrease due to simulator sickness.

Absence of measuring technique for physical responses

The simulator research is mainly based on the investigation of the behavioural, rather than psychophysiological responses of drivers. However, such measures as heart rate, respiration rate and skin conductance would provide 1) more objective evaluation of emotional regulation processes, and 2) evidence, whether behavioural and emotional responses in driving simulator are similar to these, expected from driving in the real conditions (Donkor et al., 2014). Together with the fact, that drivers tend to overestimate their driving performance, measuring of physical responses would be an asset.

Lack of corresponding scientific research

The research of elderly driving under the social pressure is relatively new. Besides the study of Chen (2013), there are no other studies that investigate thoroughly this topic. Therefore, the results of current study cannot really be supported or denied based on referencing to scientific literature.

4.2 Implications and future research

This research provides important incentives about behavioural changes of older drivers as a reaction to the social pressure on the road. Within the scope of growth of number of older drivers and increase of their average age, the scientific research becomes crucial to understand age-related driving issues, particularly driving under social pressure, as by now there is lack of studies investigating this problem.

The major implication of the research results relates to the traffic safety. In crashes, older drivers are more fragile and this leads to more fatal outcomes than for younger drivers (Hakamies-Blomqvist, 1998). Therefore, the increase of crash numbers due to the presence of social pressure might lead to corresponding increase of fatalities. To prevent this, education programs and trainings for older drivers can incorporate ways of coping with social pressure on the road to ensure personal safety. The majority of crashes occur in the complex road conditions, for instance, non-signalised intersections and turning movements against priority traffic (Cerreli, 1989; Hakamies-Blomqvist, 1993; Zhang et al., 1998; McGwin & Brown, 1999; Davidse, 2000). Again, the social pressure acting as additional stressor might provoke increase of crashes or their severity. So, the research becomes also important for the road design, where special attributes can be developed in order to address safety problem of older drivers.

For the future research, it is important to address emotional regulation of older drivers. Together with their subjective performance evaluation, additional measurement of physical responses would be an asset. Since elderly tend to overestimate their driving performance, even in complex traffic conditions, it creates a big discrepancy between objective and subjective driving performance. Therefore, additional measurements would provide more objective evaluation of the emotional regulation.

5. CONCLUSION

This report represents the results of the research dedicated to the *Effect of Social Pressure on Driving Ability of Older Drivers*. It was initiated due to the following reasons: first, it is growth of the population of older drivers (and therefore, growing impact on traffic safety); second, it is lack of comprehensive scientific researches that investigate the response of older drivers to the social pressure on the road.

The literature review showed that the population of older people is constantly increasing and this trend will continue to grow in future. For elderly it is important to stay mobile as longer as possible, therefore the population of older drivers will continue to grow as well. This has an impact on traffic safety: older drivers are more fragile in road accidents. They also have age-related declinations in health and cognitive and physical skills that are necessary for safe driving. Complex road environments and traffic situations lead to increase of workload and higher levels of stress and as a result, higher probability of making errors and mistakes. So, the increase of older drivers will have an impact on the condition of traffic safety.

The results of the practical part of the research revealed important behavioural changes of driving performance of elderly under the influence of social pressure on the road. Therefore, **social pressure has an impact on the driving ability** of older drivers. First consequence was the increase of driving speed. Secondly, both tailgater and age were causes for the increase of crashes number. Finally, the failure to give priority is only age-related. However, the subjective driving evaluation was much more positive, thus showing the overestimation of own performance on the road.

Together with age-related health declinations, social pressure affects decision-making process of older drivers and lead to larger number of errors and mistakes. Therefore, the results of this research represent an important issue not only for driving safety of older drivers, but also for the traffic safety in general.

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ANNEXES

ANNEX 1: Mini Mental State Examination test form

Mini-Mental State Examination (MMSE)

Patiënt:	Datum:
Onderzoeker:	Score: /30

1. Oriëntatie in tijd en ruimte

- **Wat is de volledige datum van vandaag?**

1.1. Tijd: Ken 1 punt per correct antwoord toe (score: 0-5)

• **In welk jaartal zijn we?**	Jaartal ☐
• **In welk seizoen zijn we?**	Seizoen ☐
• **In welke maand zijn we?**	Maand ☐
• **Welke dag is het vandaag?**	Dag ☐
• **De hoeveelste is het vandaag?**	Datum ☐

1.2. Ruimte: (score 0-5)

• **In welk land leven wij?**	Land ☐
• **In welke provincie zijn we?**	Provincie ☐
• **In welk(e) stad/dorp zijn we?**	Stad ☐
• **In welk hospitaal/centrum bent u?** *of* **Hoe is mijn naam?**	Centrum ☐
• **Op welke verdieping bent u?**	Verdieping ☐

2. Inprentingsvermogen

- **Ik noem drie woorden. Als ik ze gezegd heb, moet u ze alle drie herhalen.**
  Lees de woorden voor aan 1 woord per seconde. Laat ze daarna herhalen en noteer elk correct woord. (1 punt voor elk correct antwoord – score 0-3)

• **Sigaar**	Sigaar ☐
• **Bloem**	Bloem ☐
• **Deur**	Deur ☐

Als de patiënt ze niet correct herhaalt, zeg ze dan opnieuw voor en herhaal tot 6 maal.
Tel hier echter géén punten voor. Aantal pogingen: ☐
Onthoud deze woorden goed, want ik ga ze u straks nog eens vragen.

3. Aandacht

A. **Wilt u van het getal 100, 7 aftrekken?**
Van de uitkomst trekt u dan telkens weer 7 af en zo verder tot ik "stop" zeg.
Elke juiste aftrekking levert 1 punt op (vb. 93, 87, 80, 72, 65 geeft een score van 3).
Wanneer de eerste berekening foutief is, wordt dit als foutief aangerekend maar wel gecorrigeerd.
Daarna vraagt u: "Hoeveel is 93 min 7?" Vanaf dan vraagt u: "En verder?"

	(93) ☐
	(86) of -7 ☐
	(79) of -7 ☐
	(72) of -7 ☐
	(65) of -7 ☐

B. **Wilt u het woord "dorst" van achteren naar voren spellen?**

(1 punt voor elke correcte letter op de juiste plaats)	T ☐
	S ☐
	R ☐
	O ☐
	D ☐

Zowel test 3A als 3B worden afgenomen.
Vergelijk de scores van test A en test B en weerhoud enkel de hoogste score.
Schrap de andere en tel die niet mee in de eindscore.
Hoogste score: ☐

4. Geheugen

- **Welk waren de drie woorden die u moest onthouden?**
  (score 0-3)

Sigaar	☐
Bloem	☐
Deur	☐

5. Taal

5.1. Benoemen

• **Wat is dit?** Wijs een horloge aan.	Horloge ☐
• **Wat is dit?** Wijs een potlood aan.	Potlood ☐

5.2. Herhalen

• **Wilt u de volgende zin herhalen: "Geen als, en of maar".**	Correct ☐

5.3. Begrip

- **Neem dit papier met uw rechterhand, vouw het in twee en leg het op de grond.**

(1 punt voor elke goede handeling)	Neemt papier ☐
	Vouwt papier ☐
	Legt op grond ☐

5.4. Lezen

- **Lees wat op dit papier staat en doe wat gevraagd wordt.**

Hou het papier omhoog, waarop staat 'SLUIT UW OGEN'	Sluit ogen ☐

5.5. Schrijven

- **Kan u voor mij een zin opschrijven?**

De zin moet een onderwerp en werkwoord bevatten en betekenis hebben. Fouten in de spelling en grammatica worden niet beoordeeld.	Zin ☐

6. Constructieve vaardigheid

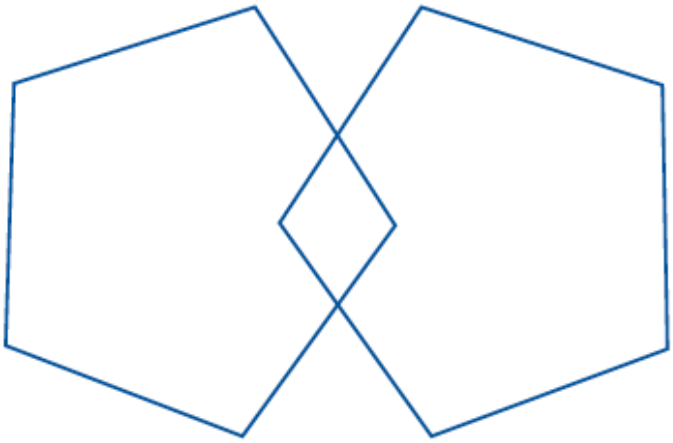
- **Kan u deze figuur natekenen?**
  Toon de twee vijfhoeken.
  Voor een correct antwoord moeten er tien hoeken zijn, waarvan er twee mekaar kruisen.

	Figuur ☐

Totaalscore

Tel alle goede antwoorden op (let op bij test 3A en 3B) en noteer het totaal in de rechterbovenhoek (maximumscore = 30)

Sluit uw ogen



ANNEX 2: NASA Task Load Index (TLX) questionnaire

Persoonsidentificatie: ..... Datum: ...../...../.....
Pre / Post

Taken Index Scenario 1

Geef aub met een X aan wat voor u van toepassing is.

Q1: Hoe mentaal belastend was de rijtaak?

Heel laag — Gemiddeld — Heel hoog

Q2: Hoe fysiek belastend was de rijtaak?

Heel laag — Gemiddeld — Heel hoog

Q3: Hoe snel of gehaast was de rijtaak?

Heel laag — Gemiddeld — Heel hoog

Q4: Hoeveel moeite kostte de rijtaak?

Heel laag — Gemiddeld — Heel hoog

Q5: Hoe onzeker was u bij het uitvoeren van de rijtaak?

Heel laag — Gemiddeld — Heel hoog

Q6: Hoe gestresseerd was u bij het uitvoeren van de rijtaak?

Heel laag — Gemiddeld — Heel hoog

Q7: Hoe verveeld was u bij het uitvoeren van de rijtaak?

Heel laag — Gemiddeld — Heel hoog

Q8: Hoe succesvol was u in het vervullen van de rijtaak?

Heel laag — Gemiddeld — Heel hoog

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Richting: **Master of Transportation Sciences-Traffic Safety**
Jaar: **2015**

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