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Age Affects Drivers' Response Times

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A B S T R A C T

In Slovenia the number of drivers over 65 is increasing every year. With age comes a decrease in psychophysical abilities, which include sensory and motoric functions and the ability of processing visual information. These changes increase the response time and decrease the driving capacity. The aim of this study was to establish a correlation between age and response time and to determine the difference in response times between men and women. In the research participated 573 randomly chosen drivers aged 19–80 with a valid driving license. We measured their response times, when stimulated by a red traffic light, on a simulator. The results clearly demonstrate that a correlation between age and the response time exists. The results show that a significant increase in response times occurs after the age of 65. In all age groups, except the oldest, women achieved longer response times than men.

Key words: *ageing, older drivers, reaction time, response time, driving capacity*

Introduction

Operating a motor vehicle is a continuous and complex sensory-motor task, which under the influence of practice and experience becomes automatic to a level of requiring almost no conscious control from the driver. Driving becomes more intricate with the increase of the complexity of the driving environment and the complexity of all possible decisions or reactions. Such circumstances occur, when one is driving in difficult conditions (weather, emotional stress, etc)[1]. The number of stimuli increases with higher velocity, denser traffic and the complexity of the driving route. The quality of driver reactions depends on his skill, knowledge and experience. The driver has to exhibit enough psychophysical capacity, e.g. being able to concentrate, to relate events to each other, to assess the current situation and to be emotionally stable[2]. The speed of ones reaction to an external stimulus (reaction time represents the time from the onset of stimuli to the beginning of a muscular reaction) is closely related to the speed of information processing. Cognitive information processing includes the perception of the stimulus and the identification, integration and classification of the information in the short-term memory. Currently processed information, a combination of all relevant parts of current perception, short--term and long-term memory[3], is located in the working memory[4]. The quality, speed and extent of perception are apart from sensory organs also effected by the state of mind (emotions, motivation, concentration, state of being awake, etc) and cognitive processes, in particular memory and thought[5].

The response time is a sum of the reaction time (RT) and movement time (MT), which represents the duration between the beginning and end of muscular contraction and reflects the speed of individual movements. In our study, RT is the time between noticing the red light and lifting the foot off the gas pedal, while MT is the time needed to move the foot of the gas pedal and apply the brakes. These times are independent of each other, as the physiological processes, which they are based on, differ. In a situation, which requires a rather low level of cognitive information processing, when there is only one stimulus and only one possible reaction, the RT is called the simple RT. When a person has to react to more than one stimulus with corresponding specific motions, it is called the disjunctive RT[6]. As a result of longer time needed for the selection of an appropriate reaction, the disjunctive RT is longer than the simple RT. The relation between the quantity of processed information and time needed to make a decision is linear[7].

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Women are, according to most studies, slightly slower to react; therefore their response times are longer[8]. Fozard et al. and Noble et al. have established that women are slower to react in all age groups except the youngest (under 15) and oldest (over 70)[9,10]. The gender differences do not decrease with acquired driving experience. This is thought to be a consequence of longer RTs, while the MTs are thought to be more or less identical for both genders[11].

The efficiency of driving depends on the driver's skill, which can be gained through experience, and on the driving capacity that is determined by his sensory, cognitive and motor skills. Younger drivers usually lack the experience, while older drivers lack the ability, however this can be partly compensated by experience and by compensation measures utilized by older drivers, e.g. substitute speed for accuracy[1]. Information processing, perception, concentration and working memory all peak in the third decade of human life, then they start to weaken[12]. Older drivers exhibit problems in recognizing important stimuli, which is probably related to a decrease in short-term memory. Attention is another problem (keeping attention, divided attention and directed attention). A lot more time is used on the level of choosing the corresponding response for each stimulus.

The decrease in motor skills has a direct effect on MT. Therefore both response time components, RT and MT, increase with age. The complexity of the given task determines, which of both is more affected. When a complex reaction follows a simple stimulus, the MT is more affected by age. In contrast, when a simple movement is preceded by a complex stimulus, the RT is more affected. Complex stimuli and complex reactions produce the biggest differences in response times between older and younger population[1].

Trained drivers react automatically to certain stimuli. Therefore training and experience could decrease the consequences of ageing. Nevertheless, the most complex road situation still require conscious control and high cognitive capacity, that is why in moments like that ageing affects the elderly the most[2].

In Slovenia the legislation requires that issued driving licenses are valid until the age of 80 (Law of traffic safety, Official gazette RS 30/98). However, the intensity of ageing varies between individuals. Establishing whether a person is still physically and mentally able to drive safely is very important, not only from the viewpoint of the individual in question, but also from the viewpoint of general traffic safety and is not meant to limit or violate his or her civil rights.

Research questions:

- Are there correlations between ages and response times separately for both genders?
- Are there differences in response times between men and women separately for age groups?
- Are there correlations between response times and short-term and long-term experiences separately for both genders?

Methods

Participants

Our descriptive study, in which we used a questionnaire and performed measurements of response times, involved a sample of 573 randomly chosen volunteers (302 men and 271 women) aged 19 to 80. The study involved active drivers (3.5% of the sample were professional drivers) with a valid driving license, which was regarded as satisfactory proof of being physically and mentally able to operate a motor vehicle by the legislation. Volunteers with coronary diseases, diseases of the locomotory system, respiratory diseases, diabetes, vision disorders (corrected) and hearing disorders were excluded from the study as were individuals with acute conditions.

Study design

The research was conducted at the Institute of Occupational Safety, Ljubljana. Members of Retirement Societies Tabor and Vic-Rudnik volunteered as elderly drivers. All participants were assorted into six age groups, all comprising of approximately the same number of men and women. The sample was stratified as regards gender, as one of our aims was to establish differences in responses between men and women in all age groups.

Prior to becoming study participants all volunteers filled in an anonymous questionnaire with their personal data (age, sex, education, driving license category, year of issue, health restrictions mentioned in the license) and their average mileage (number of kilometers driven so far and in the last 12 month).

We measured the response time of braking on a simulator. The simulator consisted of a car seat and the dashboard, which showed the current velocity (km/h), response time in seconds, reaction distance in meters and braking distance in dry and wet conditions also in meters. The acceleration pedal, clutch and brake were positioned identically to the positions in a personal vehicle. In front of the dashboard was the steering wheel; above was a row of red light bulbs. During simulation the volunteer had his/her right foot on the acceleration pedal, while the left foot was on the clutch. Pressure on the acceleration pedal started the computer program, afterwards the dashboard displayed the rising velocity. At a random velocity the program turned on the red light. The volunteer reacted by braking, which meant using the brake and the clutch simultaneously. The measurement stopped, when the brake and clutch were used. We measured the simple RT, as there was only one stimulus and only one possible reaction, i.e. braking.

All volunteers were familiarized with the simulator beforehand and a trial braking was performed before the actual experiment. Three consecutive measurements were performed on each individual. The average of all three response times was considered the result response time.

Statistics

Data were statistically analyzed with a SPSS computer program. We computed: percents, arithmetic means, standard deviations, Kolmogorov-Smirnov tests, t-tests, Pearson and multiple coefficients of correlations (α = 0.050).

Results

The distribution of the values of the measured response time describes the Gauss curve slightly skewed to the left (Figure 1). The average response time measured in our research was 0.965 s (0.932 s for men and 1.002 s for women). The shortest response time achieved was 0.75 s and the longest 1.42 s. The correlation analysis showed that the power of association between age and response time is lower for women $r = 0.306$ ($p < 0.000$) (Figure 3) than for men $r = 0.377$ ($p < 0.000$) (Figure 2). The value of the correlation coefficient for the sample was $r = 0.323$ ($p < 0.001$).

Female response times were significant longer than males' in all age groups, except over 65
($p = 0.097$) (Table 1 and Figure 4). Another difference between genders, which emerged in our study, was that female response times changed differently with age than male response times. For women, the first age group (18–24) achieved longer response times than the most successful second age group. Contrary to women, men achieved similar results in the first three age groups (up to 44 years); the response times increased with age in older groups.

With the use of multivariate analysis we wished to establish the effect of short-term and long-term experiences on the response time. First we computed Pearson coeffcient of correlation separately for both genders and determined a weak negative correlation between response times and short-term experience for men r = –0.181 ($p = 0.002$) and women r = –0.174 ($p = 0.004$), both statistically significant. We have not established any such correlation for long-term experiences. The multiple correlation coefficients between response times and short-term and long-term experiences for men was R = 0.192 ($p = 0.004$) and women R = 0.181 ($p = 0.011$)), both statistically significant.

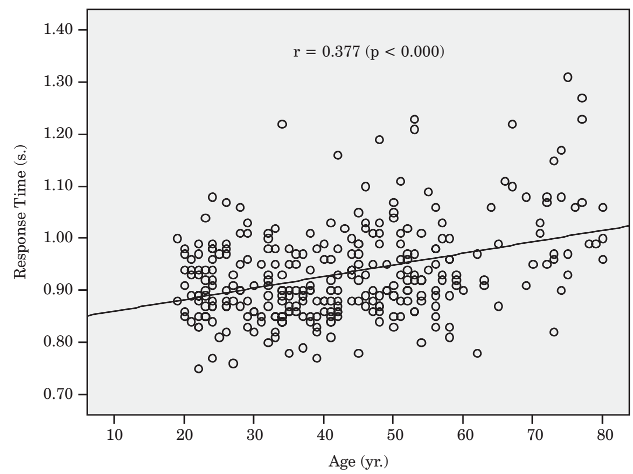

Fig. 2. Scattergram of correlation between age and response time for men.

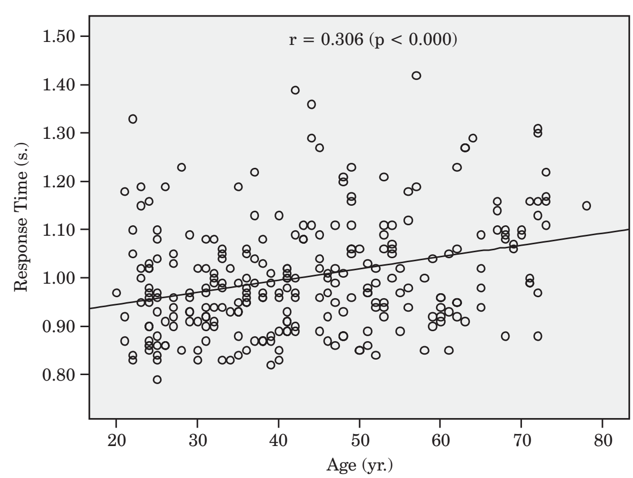

Fig. 3. Scattergram of correlation between age and response time for women.

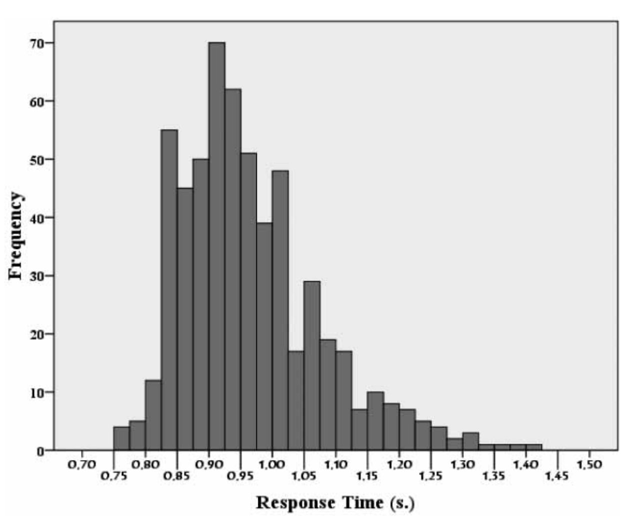

Fig. 1. Frequency distribution of the drivers' response times, from the onset of the red light to braking.

Discussion

Our measured response time included the simple RT and the MT needed to perform a simple action. Considering the task, i.e. braking, which was almost automatic, the RT in our study did not include time needed for extensive information processing by central nervous system. If we also consider that the processing part of RT changes with age most of all, while other parts of RT and MT do not change as much, when simple actions are

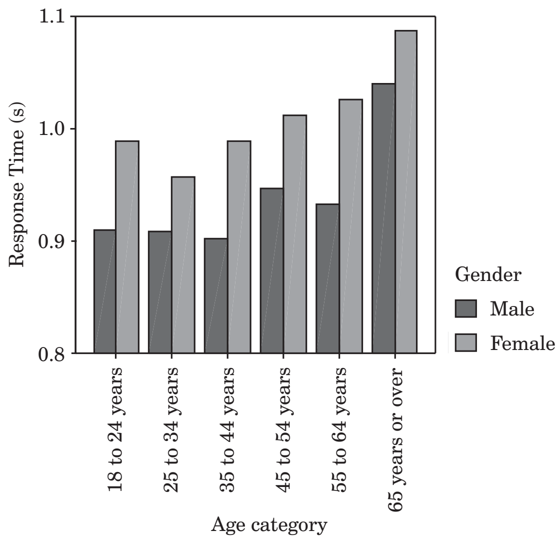

Fig. 4. Average response times with regards to age and gender.

concerned[13], we can conclude that our results cannot convey the entire change in reaction quality caused by ageing. To reach such results our volunteers would have to complete further and more complex tasks. By analyzing several different studies Spirduso[1] has determined that the average correlation coefficient for simple RT was 0.33, while the correlation coefficient for disjunctive RT was 0.46. Complex stimuli combined with complex reaction provided the researchers with the highest levels of correlation (0.62).

The effects of ageing are probably bigger than we can ever demonstrate in individual studies, partly because of selection bias. Mostly studies only include those older drivers that are still in good psychophysical condition. The potential influence of ageing does not manifest itself in these individuals, as it would in other drivers of the same age group. Some of these other drivers have perhaps already mostly given up driving, as a result of their incapacity, but nevertheless still drive from time to time. The compensation measures (which are very hard to measure) undertaken by elderly drivers are another reason for the difficulty in conducting such studies[14].

The response time values in various studies differ for as much as four times. This is a consequence of various measurement methods, i.e. different simulators (different light stimuli, distances between pedals, etc.) and also the level of expectation of the stimulus. A stimulus, which is not expected, almost doubles the response time. That is why experiments, when the participants are warned about the stimulus, are considered to provide the best quality of data. Average response times in such cases are approximately 0.70 s. In reality response times are at least 0.3 s longer than those acquired from experiments on simulators[8].

Most studies established a gender difference in response times. Men were usually faster than women, which is in accordance with our results. Some studies established a difference only in the RT and found no evidence for differences in MT. Adam et al. claim that men and women use different strategies when processing information[11]. Women mostly use slower verbal strategies, while men use relatively faster visual strategies. Warshawsky-Livne and Shinar provided evidence that women achieve longer MT than men[13]. Yandell and Spirduso claim that the gender differences have no neurophysiological background; furthermore they are caused by different expectation of society regarding physical activity of men and women[15].

By comparing the average response times of individual age groups we determined that the differences were statistically significant (ANOVA, p = 0.000). However, multiple analysis has only demonstrated statistically significant differences between the first (18–24) and last (over 65) male age group and between the second (25–34) and last (over 65) female group. Therefore we concluded that significant differences appear only after the age of 65. The oldest groups achieved in average 12.3% worse

TABLE 1
VALUES OF RESPONSE TIMES WITH REGARDS TO AGE AND GENDER

Age group	Sex	Number of drivers	Average response time [s]	Standard deviation	t-value	p
18–24	M	46	0.9096	0.06556	–3.244	0.002
	F	30	0.9883	0.12200		
25–34	M	62	0.9085	0.08016	–3.120	0.002
	F	60	0.9567	0.09006		
35–44	M	65	0.9018	0.06675	–5.149	0.000
	F	64	0.9895	0.11905		
45–54	M	67	0.9466	0.09130	–3.659	0.000
	F	56	1.0116	0.10583		
55–64	M	30	0.9323	0.07450	–3.125	0.003
	F	31	1.0255	0.14767		
over 65	M	32	1.0394	0.11556	–1.688	0.097
	F	30	1.0867	0.10423		

results than the youngest. Johnson et al. and Birren et al. determined similar differences (13% and 20%) between 20 and 60 year olds in their study of the simple RT[16,17]. Although differences between other age groups are present (according to literature the RT starts increasing by the age of 40), they are not statistically significant[18].

Experience effects the response time the most, when complex reactions or complex stimuli come into play. The disjunctive RT is affected most of all, as the selection of an appropriate reaction can be almost automatic with sufficient acquired experience. Breaking when encountered by a red light test is such an automatic reaction, therefore when testing response times on the simulator we cannot expect big differences in experience. In reality there is always more than one stimulus. If the test would be constructed differently, so that the driver would have to brake when the safety distance between his/her vehicle and the vehicle in front would become critical, experience would probably be a much more important factor[19].

Conslusions

We established a correlation between age and response time by measuring the response time of braking at a red light signal. The power of correlation was slightly higher for men than for women. Our results are similar with the data acquired by other researchers studying the correlation between simple RT and age. Response times increase significantly after the age of 65, however due to interindividual differences in the ageing process functional age is a more reliable indicator of reaction speed than chronological age.

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UTJECAJ DOBI NA ODZIVNO VRIJEME VOZAČA

S A Ž E T A K

U Sloveniji se svake godine povećava broj vozača starijih od 65 godina. S godinama počinju slabiti phihofizičke sposobnosti, uključujući osjetne i motoričke funkcije te mogućnost obrađivanja vizualnih informacija. Takve promjene povećavaju odzivno vrijeme i smanjuju sposobnost za vožnju. Cilj ovog istraživanja bio je dokazati suovisnost između dobi i odzivnog vremena i utvrditi razliku odzivnog vremena kod muškaraca i žena. U istraživanju je sudjelovalo 573 slučajno izabranih vozača u dobi od 19 do 80 godina s valjanom vozačkom dozvolom. Mjerili smo njihova odzivna vremena koja je potaklo crveno svjetlo na semaforu simulatora. Rezultati jasno ukazuju na to da suovisnost između dobi i odzivnog vremena postoji. Rezultati pokazuju da se izrazit porast odzivnog vremena javlja nakon 65. godine života. U svakoj životnoj dobi, osim u najstarijoj, žene su postizale duža odzivna vremena od muškaraca.