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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

The effect of a cognitive and motor dual task on simulated driving performance for young, middle-aged and older drivers

Charlotte Dekeyser
Laura Houtevels

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij kinderen

PROMOTOR :
Prof. dr. Raf MEESEN

BEGELEIDER :
Mevrouw Siel DEPESTELE

2021
2022

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Acknowledgement

In the second master of physiotherapy, we were granted the opportunity to investigate driving performance thoroughly. This thesis is about the effect of dual tasks on driving performance in different age groups. We learned to a large degree about writing a thesis, including research of reliable sources, statistical analysis and academic writing. We were given the possibility to discuss and reflect on our obtained results, which gave us a critical mindset. We want to give our thanks to everyone who helped during this process. We couldn't have written this thesis without their cooperation.

First, we want to sincerely thank our promotor Prof. Dr. Raf Meesen and supervisor Ms. Siel Depestele for their great guidance through this thesis. They gave constructive feedback on all of our questions and they encouraged us to dig deeper and broaden our minds.

We want to thank the research team for performing the recruitment and the data acquisition of this investigation. They provided a lot of data, which was shared with us in confidence. This created many possibilities for extensive research. We also want to thank the participants for clearing their schedule and helping us with providing all the necessary data.

Finally, we want to thank our friends and family for their support and trust. They also took the time to help us with spelling and grammar during the writing process, which helped us to hand in a thesis of good quality.

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Siting

According to Reuter-Lorenz (2002), older people show an underactivation of certain brain regions which are more active in younger adults when performing certain tasks. Many of these brain regions are important for cognitive functioning during driving, such as reaction time (Stenneken, Aschersleben, Cole, & Prinz, 2002) and response accuracy or both (Ninio & Kahnemn, 1974; Salvia et al., 2016). Depestele et al. (2020) found that older drivers also showed a decreased driving performance compared to younger drivers, such as decreased lane keeping behaviour and having a less consistent driving speed. During driving, the driver is confronted with having to perform different kinds of dual tasks, such as interacting with the in-car display and conversing with a passenger or on a cell phone. According to Dragutinovic & Twisk (2005), using a phone while driving has a negative impact on driving performance. This includes slower braking reaction times, slower reaction times to traffic events, missing more traffic events and more risk taking behaviour. They also found that there was not much difference between handheld and hands free phone conversations and that the negative effect of the dual task was more pronounced in difficult driving situations. According to Depestele et al. (2020), both young and older drivers showed a negative impact of dual tasks on driving performance, such as lane keeping and steering behaviour. According to the National Centre for Statistics and Analysis (2020), performing a dual task while driving was a leading cause for crashes. Since the worldwide population is showing an increase in average age (World Health Organization, 2015), this part of the population is becoming a larger portion of drivers on the road. Due to the cognitive declines in this population, it is important to focus on the effects on driving performance for these drivers, more specifically the effects of dual tasks.

This driving study is part of an ongoing research project in the broader domain of brain research within the University of Hasselt. The project has the main aim of investigating the underlying neural correlates of motor control during driving for older people, which was done through recording brain activity with electroencephalography (EEG). Our study focussed purely on driving performance as an outcome measure with an added sub research question about the subjective workload experienced by the participants. Data of this study was already gathered by the start of this master's thesis. We were able to formulate our own research questions and select the corresponding data.

Both students were involved in the recruitment of participants and were each present in one testing session. This was to get accustomed with the protocol and data acquisition. Both students also were able to experience the driving simulator themselves to better understand the equipment and driving scenarios. At first we were presented with raw data to determine the outcome measures. Due to the complexity of the driving simulator data, processing was done by our supervisor who converted the data to more easily usable data ready for import to the statistical software. This was also done for the data from the questionnaires and the dual task performance. For the academic writing process, our supervisor was also involved with giving feedback on the introduction. Furthermore, we got feedback on the content, such as the method to use for the statistical analysis.

Depestele, S., Ross, V., Verstraelen, S., Brijs, K., Brijs, T., van Dun, K., & Meesen, R. (2020). The impact of cognitive functioning on driving performance of older persons in comparison to younger age groups: A systematic review. *Transportation Research Part F-Traffic Psychology and Behaviour, 73*, 433-452. doi:10.1016/j.trf.2020.07.009

Dragutinovic, N., & Twisk, D. (2005). Use of mobile phones while driving - effects on road safety: a literature review.

Li, S.-C., Lindenberger, U., Hommel, B., Aschersleben, G., Prinz, W., & Baltes, P. B. (2004). Transformations in the couplings among intellectual abilities and constituent cognitive processes across the life span. *Psychological science, 15*(3), 155-163.

National Center for Statistics and Analysis. (2020). *Distracted driving 2018*. National Highway Traffic Safety Administration.

Ninio, A., & Kahneman, D. (1974). Reaction time in focused and in divided attention. *Journal of Experimental Psychology, 103*(3), 394.

Reuter-Lorenz, P. (2002). New visions of the aging mind and brain. *Trends Cogn Sci, 6*(9), 394. doi:10.1016/s1364-6613(02)01957-5

Salvia, E., Petit, C., Champely, S., Chomette, R., Di Rienzo, F., & Collet, C. (2016). Effects of Age and Task Load on Drivers' Response Accuracy and Reaction Time When Responding to Traffic Lights. *Front Aging Neurosci, 8*, 169. doi:10.3389/fnagi.2016.00169.

Stenneken, P., Aschersleben, G., Cole, J., & Prinz, W. (2002). Self-induced versus reactive triggering of synchronous movements in a deafferented patient and control subjects. *Psychological research, 66*(1), 40-49

World Health Organization. (2015). *World report on ageing and health*. Geneva, Switzerland.

The effect of a cognitive and motor dual task on simulated driving performance for young, middle-aged and older drivers.

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UNIVERSITY OF HASSELT

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Abstract

Background: Older drivers show higher risk for a deteriorated road safety, since they experience more health issues and cognitive declines. Distraction when driving in the young population can lead to crashes and is related to their shorter driving experience. Driving is an activity that is composed of motor and cognitive dual tasks. The distraction that these tasks create, can lead to more safety errors from young to old drivers.

Objectives: The objective of this study was to investigate the effect of dual tasks on driving performance and subjective workload between three age groups.

Participants: In total, 81 participants (27 young range 25-35y, 25 middle-aged range 50-60y and 29 old aged 65+y) were assessed in a driving simulator when performing a motor dual task (pressing the gas pedal) and a cognitive dual task (PASAT).

Measurements: The primary outcome measure is driving performance, expressed in Standard Deviation Lane position, Heading Error, Steering Reversal Rate and Track. The secondary outcome measures are the performance of the cognitive and motor dual task and the subjective outcome measures, including mental load, physical load, time pressure, performance, overall load and frustration.

Results: The older group showed more deterioration in driving performance compared to the middle-aged and young group. Secondly, the older group performed worse on both dual tasks. However, no difference was found in driving and not driving. At last, the older group showed the highest subjective workload when performing dual tasks compared to the other groups.

Conclusion: The presence of dual tasks when driving lead to a deteriorating driving performance for all ages and they entail a higher subjective workload, especially for the older population. In general, motor dual tasks had a more negative influence on driving performance compared to cognitive dual tasks.

Keywords: Driving performance, subjective workload, dual task, cognitive, motor, young, middle-aged, old

1. Introduction

Driving a motor vehicle has been integrated as an activity of daily life for adults worldwide. Evidence showed that there is engagement in distracting activities in more than 50% of the driving duration, which leads to a higher rate of crashes (Dingus et al., 2016). These activities consist of e.g., holding a cell phone or interacting with a passenger. They calculated that 36% of crashes could be avoided if there were no distractions present (Dingus et al., 2016). McEvoy, Stevenson, and Woodward (2007) showed that more than 30% of serious crashes are related to the engagement in a dual task while driving. Distraction can be explained as diminished attention to the primary task, in this case driving. In Chaparro, Wood, and Carberry (2005), multitasking during driving has a significant detrimental effect on driving performance.

To this day, the current population of older drivers consists of 12-15% of the driving population in Western countries and it is still growing fast (Cantin, Lavallière, Simoneau, & Teasdale, 2009). Older people experience more health issues such as cognitive declines, impaired vision and functional limitations, which interferes with their driving abilities (Bhojak et al., 2021). This is why they show higher risk for a deteriorated road safety, despite the fact that older drivers show lower crash rates compared to younger drivers (Marmeleira, Godinho, & Vogelaere, 2009). In Chaparro et al. (2005), the cognitive function of young and older drivers was investigated using the Digit Symbol Substitution task (DSS) . This task seems to reflect selective attention and speed of information processing, which showed to be the best predictor of driving performance with or without the presence of a visual dual task. The conclusion was that older people scored significantly worse on cognitive tests in comparison to the young participants. This is why the decline in driving performance can be explained by cognitive ageing, rather than chronological ageing. Lyon, Brown, Vanlaar, and Robertson (2021) showed that for every increase of 10 years in age in drivers, they tend to text 44% less, use a handheld phone 38% less and use hands-free phones 28% less, which leads to the lower crash rates. Distracting activities during a crash were most reported among the younger group, associated their shorter driving experience (McEvoy et al., 2007).

Driving is an activity which is composed of motor and cognitive dual tasks, e.g. pushing buttons and listening to a navigation system. Multiple studies investigated the effect of a dual task on driving performance. In one study, dual task interference, which includes distraction from the baseline task, was investigated while performing hand tasks including tapping and releasing buttons while driving. The dual task consists of the Stroop task (Periáñez, Lubrini, García-Gutiérrez, & Ríos-Lago, 2021), which measures the cognitive load. The driving performance was expressed in terms of reaction time, which could be used as a parameter to investigate dual task interference. The study concluded that the reaction time was significantly lower while performing the dual task, which indicated the presence of a higher cognitive load in general (Kang, Shin, Yun, Park, & Park, 2018). In Makishita and Matsunaga (2008), reaction time increased for all age groups while driving when committing to a mental calculation, and increased more remarkably for the older drivers. A higher mental workload could be the cause of errors while driving. Cantin et al. (2009) showed that there was a higher mental workload at intersections and this increased for more complex driving manoeuvres. This study concluded that driving led to a higher mental workload for older drivers, which led to more safety errors in comparison to the younger drivers.

The objective of this study is to investigate the influence of a dual task on driving performance for young, middle-aged and older drivers. The effects of dual tasks on the middle-aged group have not yet been clearly investigated. In Aksan (2018), a middle-aged group was included. They stated that the older group performed significantly worse on the secondary task while driving, compared to the middle-aged group. In Karthaus, Wascher, Falkenstein, and Getzmann (2020), the middle-aged group showed the same results as the older group in the presence of a dual task. Secondly, we want to investigate the differences between a motor and a cognitive dual task in all age groups. Liu and Ou (2011) stated that a cognitive dual task, e.g. using a hands-free phone during driving, creates a high mental strain and has more influence on driving performance for the older group compared to younger. A motor dual task, e.g. typing a number on a keypad while driving, could induce slower driving and more distraction, compared to driving without dual task (Wechsler et al., 2018). It is not clear whether a cognitive task leads to a higher decline in driving performance compared to a motor dual task. At last, we want to examine what the difference is in subjective workload while performing a dual task during driving. Jackson, Shaw, and Helton (2022) showed a significant increase in subjective workload in a dual task condition in general, compared to a single task. We hypothesise that dual tasks have a significant influence on driving performance and subjective workload, which increases with age.

2. Methods

2.1 Participants

Recruitment was done through word to mouth, leaflets and social media. In total 81 participants were included in the sample. They were divided into three different age groups: 27 young drivers (range 25 - 35y), 25 middle-aged drivers (range 50 - 60y) and 29 older drivers (65+y). Inclusion criteria were as follows: a) normal cognitive functioning measured as a score of 23 or higher on the Montreal Cognitive Assessment questionnaire, b) normal or corrected vision according to the Snellen test (>0.3), c) normal hearing or corrected with a hearing aid, d) in possession of a valid driver's licence. Participants were excluded for following reasons: a) neurologic or psychiatric disorder, b) physical disability which prevents the participant from executing the driving simulator task, c) alcohol or drug addiction, d) currently taking medication that has an influence on the central nervous system, e) history of brain damage or skull fracture. During the first session, all participants were informed about the requirements of the study. They read and signed an informed consent declaration. No participants got excluded throughout the course of this study. The study was conducted in compliance with the Committee for Medical Ethics of the University of Hasselt (UHasselt, 2022).

The demographic variables of the participants are listed in table 1. The three age groups differed in mean age ($p<0.0001$), MOCA ($p= 0.0263$) and weekly mileage ($p= 0.0024$). Post hoc analysis revealed a significantly higher MOCA score in the young group compared to the middle-aged group ($p= 0.0161$) and a significantly higher weekly mileage in the young group compared to the middle aged ($p= 0.0110$) and older group ($p= 0.0011$). No significant difference was found between the sex in all groups.

2.2 Procedure

2.2.1 Apparatus

A driving simulator (Systems of the Technology Interactive Simulator, STISIM) by Systems Technology, Inc. (Hawthorne, CA) (Systems Technology, 2020) was used. This simulator consists of a steering wheel, pedals and screens to simulate the driving environment. In this study, only the middle screen in front of the driver was used. The pedals were not used for controlling the driving speed. Instead, only the gas pedal was used to perform the motor dual task (DT), which will be explained further.

Table 1

Demographic variables

	Y (25 – 35y)	MA (50 – 60y)	O (65+y)	P-value
Age	M= 27.2 SD= 2.7	M= 55.3 SD= 2.9	M= 68.8 SD= 3.0	P<0.0001
Sex (m/f)	15/12	10/15	17/12	P=0.3522
MOCA	M= 28.1 SD= 1.3	M= 27.2 SD= 1.3	M=27.3 SD= 1.3	P=0.0263
Snellen	M= 0.94 SD= 0.12	M= 0.86 SD= 0.19	M=0.75 SD= 0.26	/
Weekly mileage (km)	M=297.1 SD= 205.8	M=184.4 SD= 182.9	M= 152.4 SD= 158.3	P=0.0024

Y: Young, MA: Middle-Aged, O: Older

2.2.2 Study design

This observational study consisted of two sessions. In the first session, a screening was done where the participants completed clinical tests. These included the Snellen chart for visual acuity (Azzam D., 2022) and the Montreal Cognitive Assessment (MoCA), which is shown to be more sensitive for detecting mild cognitive impairment compared to the often used Mini Mental State Examination (Nasreddine et al., 2005). Participants were also asked about their weekly mileage. After this, they had to do a five minute drive to get accustomed with the driving simulator and were asked for symptoms of simulator sickness through the Simulator Sickness Questionnaire (SSQ) (Kennedy, Lane, Berbaum, & Mg, 1993). These include symptoms such as nausea, dizziness, eye strain and headache, with nausea being the most common symptom linked to drop out of participants (Balk, Bertola, & Inman, 2013; Brooks et al., 2010). The second session consisted of a five minute difficulty determination block to determine the baseline speed at which the participant could drive comfortably. This was done so that the baseline drive (BL) would have an equal difficulty level for all participants. The driving speed was regulated by the simulator depending on how well the participant was able to keep the car on the road. When the participant would lose control often, the simulator would lower the speed the participant was driving at. When the lane keeping was too easy, the speed would go up. After this, participants were checked for simulator sickness. Next, a five minute baseline drive was carried out at a constant speed which was 20% lower than the speed which was determined in the difficulty determination block. This was to ensure the primary lane keeping task was not too difficult. A subjective workload questionnaire and a simulator sickness questionnaire were taken. After this, participants had to perform the driving task at the same speed as the baseline condition in combination with a cognitive and a motor DT. Before starting each DT drive, participants had to perform the DT without driving to get familiarised with the task. Each DT drive consisted of two driving blocks of five minutes. The order of the DT drives was pseudo-randomized. At the end of each DT drive the subjective workload questionnaire was taken. Participants were also checked for simulator sickness after finishing both DT drives.

2.2.3 Driving scenario

The driving scenario consisted of a simple road with straight sections and curved sections. There was no midline or oncoming traffic to minimise distraction. Participants had to perform a lane keeping task in which they were instructed to drive in the middle of the road. The road was surrounded by grass on which the participant could drive when steering control was lost. A sound indicated when the participant went off the road. The width of the road was larger in the older group to provide a more equal difficulty level between all age groups.

2.2.4 Motor dual task

For the motor DT, two horizontal bars were shown on the screen. One bar was coloured a certain amount. The participant was instructed to fill in the other bar to the same amount by pressing in the pedal with his foot. By pressing the foot in further, the coloured portion would increase. When the coloured portion of the first bar changes, the participant had to adjust the pressure of his foot to meet the same amount in the second bar. Accuracy was measured by the distance between the asked pressure and the actual pressure given by the participant.

2.2.5 Cognitive dual task

The cognitive DT consisted of the Paced Auditory Serial Addition Task (PASAT) (Gronwall, 1977). A number was shown on the screen for five seconds and had to be memorised by the participant. When the first number disappeared, a second number was shown. The participant had to sum up the first and second number and verbally communicate the answer to the examiner. Whenever a new number was shown, participants had to sum up the previous and the new number. The answer was scored as correct, incorrect or missed.

2.2.6 Primary outcome measures

The primary outcome measures represent the overall driving performance. These are: Standard Deviation of Lateral Position (SDLP), Heading Error (HE), Steering Reversal Rate (SRR) and track. The SDLP is the distance in metres between the centre of the vehicle relative to the midline of the road. This is a measure to determine the amount of vehicle weaving. HE is defined as the angle (degrees) of the vehicle position in relation to the road. The more accurate the vehicle follows the curvature of the road, the smaller the HE will be. SRR measures the magnitude and rate at which a driver performs steering wheel reversals and is quantified in degrees/second. This is a measure for capturing steering corrections and has been shown to have a decent sensitivity when performing a cognitive DT while driving (Markkula & Engström, 2006). Finally, track is the percentage of distance the driver went off the road.

2.2.7 Secondary outcome measures

The secondary outcome measures include the performance of the cognitive and motor DT and the subjective outcome measures. The cognitive and motor DT performances were measured each when driving at a comfortable speed. They were also measured without driving and were quantified in percentage. The subjective outcome measures were scored through the NASA Task Load Index (NASA-TLI) (Hart & Staveland, 1988). According to Pauzie (1997), this assessment tool has been shown to have a good sensitivity and has been used often in driving situations, which also include DT conditions. It consists of 6 subscales which evaluate mental load, physical load, time pressure, performance, overall load and frustration. These were scored on a visual analogue scale, with a higher score meaning higher workload. Mental load was described as the amount of thinking, calculating, memorising, etc. that was needed during the task. Physical load consisted of activities such as pushing, pulling, turn controlling, etc. For the item time pressure, participants were asked how they experienced the pace of the task. Performance measured how successful the participants believed they were in accomplishing the task. The item overall load asked how much mental and physical labour was required for reaching the performance level indicated earlier. Finally, frustration gauged how much irritability, stress, insecurity, etc. was experienced while performing the task.

2.3 Data analysis

All primary outcome measures and the motor DT performances were registered by the driving simulator operating system. The cognitive DT performances were registered by the examiner and the subjective outcome measures were taken via questionnaires. All data was saved to a txt-file that was uploaded to JMP® Pro 16.2.0 (LLC, 2022). Analysis was done using mixed models with a significance level of $\alpha = 0.05$. According to Schielzeth et al. (2020), mixed models show good robustness that allow it to be used even if the distributional assumptions are not met. Post hoc analysis was done using a Student's t test with Bonferroni correction (α^*). Differences between groups (Y, M-A, O) and tasks (BL, cognitive DT, motor DT) were analysed. For the primary outcome measures differences between the type of road (Curve, No Curve) were also analysed.

Analysis of the demographic characteristics was done through JMP® Pro 16.2.0. The sex was analysed with categorical analysis using the Pearson test, since the expected values were ≥5. Age, the weekly mileage and data from the MOCA test were analysed using Kruskal-Wallis for nonparametric data, since these characteristics were not normally distributed. Significant effects were post-hoc analysed with Wilcoxon Each Pair, for which a Bonferroni correction was done. For the Snellen test, no further analysis was performed due to the data not being normally distributed and having unequal variances.

3. Results

A detailed overview of all p-values can be found in table 1 - 20 in the appendix A.

3.1 Driving performance

3.1.1 Standard deviation of lane position

A significant interaction effect was found between group and task (p< 0.0001), shown in figure 1. The older group and middle-aged group showed a significantly higher SDLP on the motor DT compared to the BL and cognitive DT (p<0.0014). In the young group no significant effects were found between tasks (p>0.0014). For the motor DT, the older group had a significantly higher SDLP compared to the young and middle-aged group (p<0.0001). For the BL, the older group had a significantly higher SDLP compared to the young group (p=0.0007).

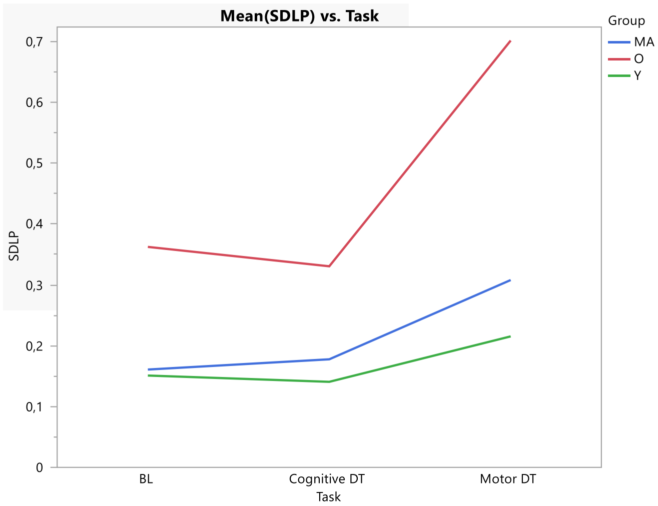


*Figure 1: SDLP (Group*Task)*

3.1.2 Heading error

A significant interaction effect was found between group and task (p<0.0001), shown in figure 2. The middle aged and older group showed a higher HE while performing the motor DT in comparison to BL and the cognitive DT (p<0.0001). While performing the motor DT, the HE of the middle-aged group was significantly lower than the older group (p<0.0001) and significantly higher than the younger group (p<0.0001). The older group showed a significantly higher HE compared to the young group (p<0.0001).These results showed that the HE is significantly increasing with age when performing a motor DT. During BL and the cognitive DT, the HE was significantly higher in the older group compared to the young group (p<0.0001). However, no effect was found in the middle-aged group compared to the young or older group (p>0.0014). In the older group, no difference in HE was found when performing a cognitive DT in comparison to BL (p=0.9948). In the young group no effect of HE was found between all three driving conditions (p>0.0014). At last, a significant effect of road was observed (figure 3), with a higher HE in curved road sections compared to straight sections in all age groups (p<0.0001).

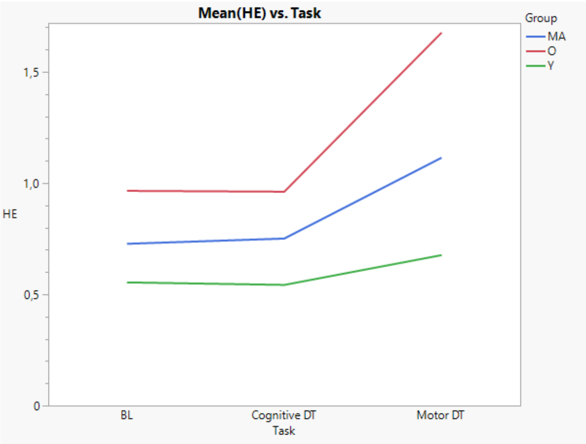


Figure 2: HE (Group*Task)

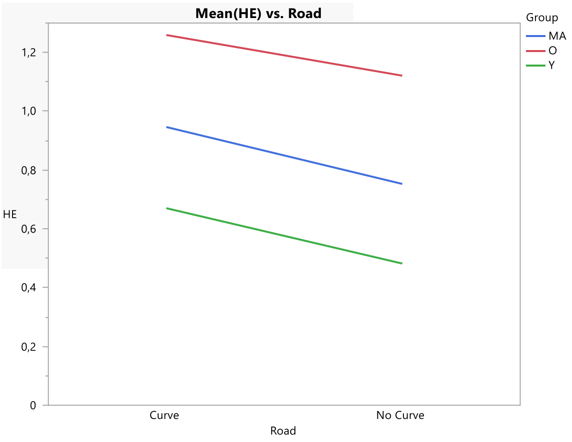


Figure 3: HE (Road)

3.1.3 SRR

There was a significant interaction effect between group and road (p=0.0023), shown in figure 4. The young group had a significantly higher SRR in the curved road sections compared to the straight sections (p=0.0019). For the middle aged and older group no significant effects were found for the type of road (p=0.7852 and p=0.0039 respectively). In the straight sections the older group had a significantly higher SRR than the middle-aged group (p=0.0020), but this was not significant compared to the young group (p=0.0447). For the curved road sections there were no significant effects found between the groups (p>0.0033). There was also a significant interaction effect found between group and task (p=0.0008), shown in figure 5. The older group had a significantly higher SRR in the BL compared to the motor DT (p<0.0001). They also had a higher SRR in the cognitive DT compared to the BL and motor DT (p<0.0001). Both the middle-aged group and young group had a significantly higher SRR in the cognitive DT compared to the BL and motor DT (p<0.0001), and no significant differences were found between the BL and motor DT (p>0.0014). For the cognitive DT the older group had a significantly higher SRR than the middle-aged group (p=0.0008). For both the BL and motor DT, no significant differences were found between the age groups (p>0.0014).

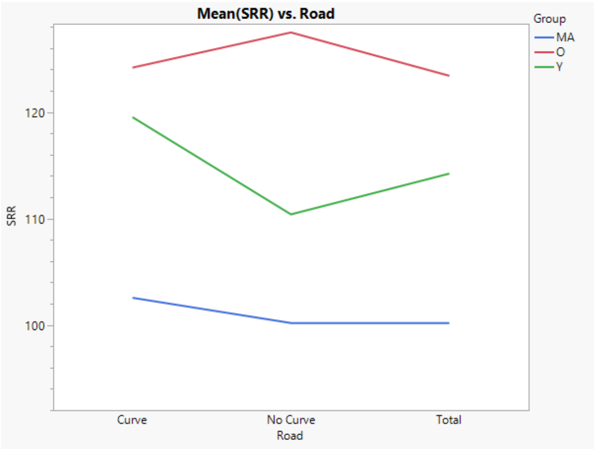


*Figure 4: SRR (Road*Group)*

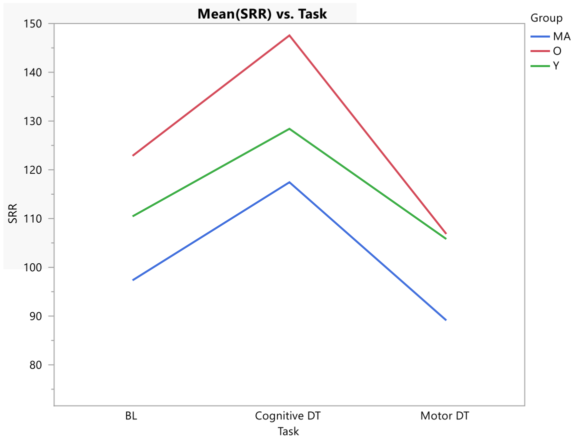


*Figure 5: SRR (Group*Task)*

3.1.4 Track

There was a significant interaction between road and task (p=0.0127) and between group and task (p= 0.0002), shown in figures 6 and 7. When driving on a curved road section or on a straight road, the motor DT led to a higher track in comparison to BL and the cognitive DT (p<0.0001). No significant effect was found between the cognitive DT and BL (p>0.0033). During BL and the cognitive DT, driving on curved road sections led to a significantly higher track compared to driving on straight roads (p<0.0033). When performing the motor DT, no significant effect of road was found (p=0.8360). In all age groups, track was significantly higher when performing the motor DT compared to BL and the cognitive DT (p<0.0001). BL compared to the cognitive DT led to no significant effect (p>0.0033). During BL and the cognitive DT, no significant effect was found between all groups (p<0.0001). In the case of the motor DT, a significant effect was found in the younger group compared to the middle-aged (p=0.0002) and the older group (p=0.0002). With this DT, no effect was found between the middle-aged and the older group (p=0.9366).

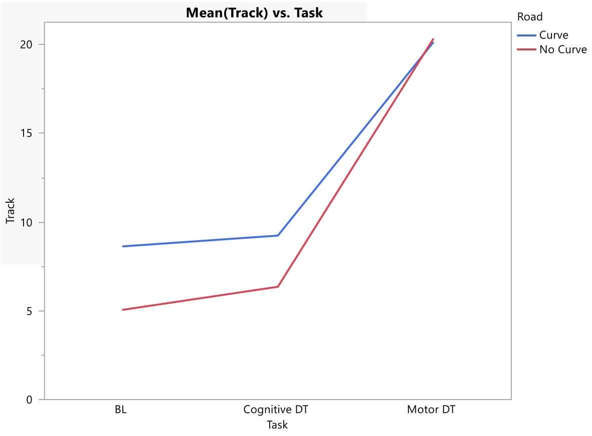


*Figure 6: Track (Road*Task)*

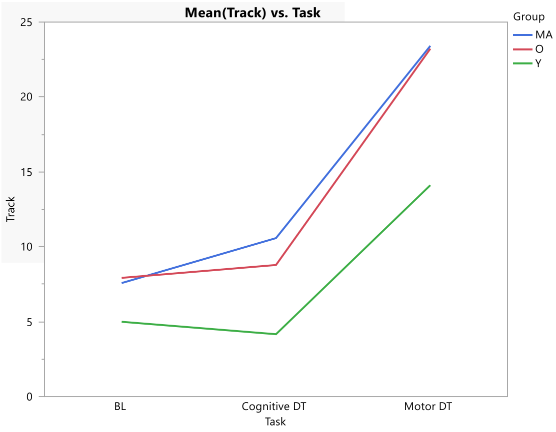


*Figure 7: Track (Group*Task)*

3.2 Dual task performance

3.2.1 Percentage cognitive

There was a significant difference found between groups (p=0.0065), shown in figure 8. The score on the cognitive DT was significantly lower for the older group compared to the young group (p=0.0019). Compared to the middle aged group, no significant difference was found (p>0.0167). There was no significant difference found between the DT performance while driving and without driving (p=0.1084).

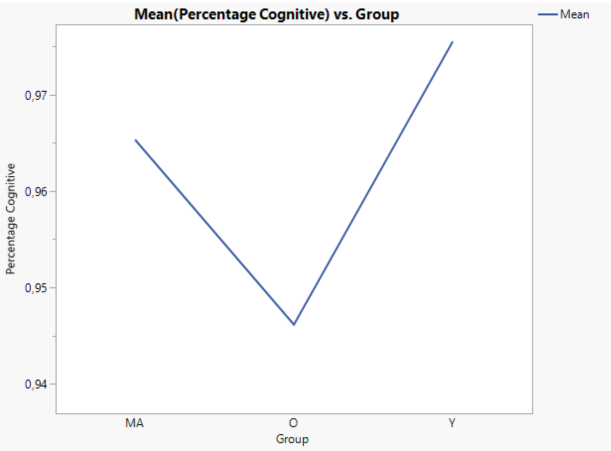


Figure 8: Percentage cognitive (Group)

3.2.2 Percentage motor

There was a significant difference found between groups (p=0.0166), shown in figure 9. The score on the motor DT was significantly lower for the older group compared to the young group (p=0.0043). Compared to the middle-aged group, no significant difference was found (p>0.0167). There was no significant difference found between the DT performance while driving and without driving (p=0.4303).

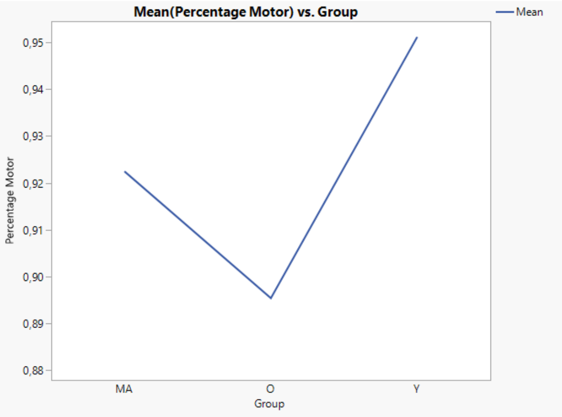


Figure 9: Percentage motor (Group)

3.3 Subjective workload

3.3.1 Mental load

Significant effects were found between tasks (p<0.0001), shown in figure 10. The mental load is significantly higher while performing a DT in comparison to BL for all age groups (p<0.0001). No difference was found between age groups (p= 0.0793).

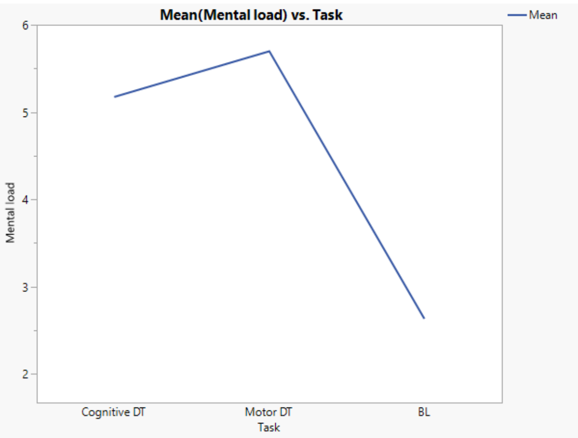


Figure 10: Mental load (Task)

3.3.2 Physical load

Significant effects were found for tasks (p<0.0001) and groups (p= 0.0017), shown in figures 11 and 12. The physical load is significantly higher in the middle-aged (p=0.0030) and older group (p=0.0012) in comparison to the young group. The physical load was higher while performing the motor DT in comparison to the cognitive DT or BL (p< 0.0001). Physical load was also significantly higher for the cognitive DT in comparison to BL (p=0.0002).

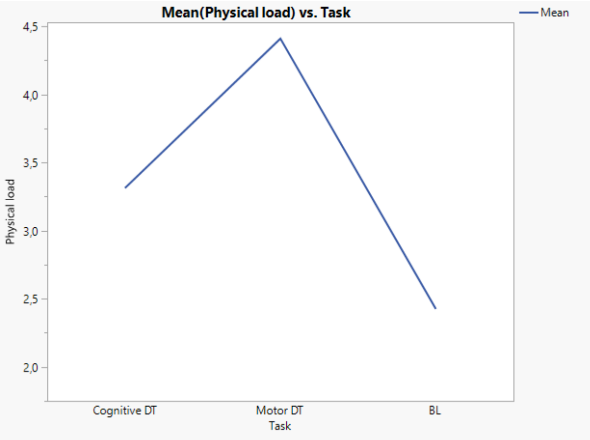


Figure 11: Physical load (Task)

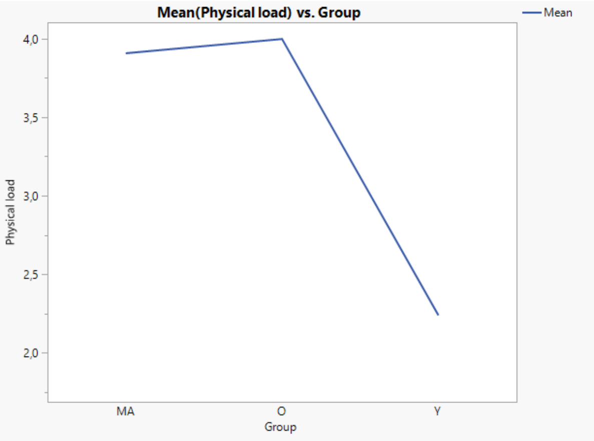


Figure 12: Physical load (Group)

3.3.3 Time pressure

Significant effects were found between groups (p=0.0197) and tasks (p<0.0001), shown in figures 13 and 14. Time pressure was significantly higher in the older group while driving in comparison to the young group (p=0.0055). There was no difference between the middle-aged and the other groups (p>0.0167). Time pressure was not different between the motor and cognitive DT's for all age groups (p=0.0226). In comparison to BL, the cognitive or motor DT's showed more time pressure (p<0.0001).

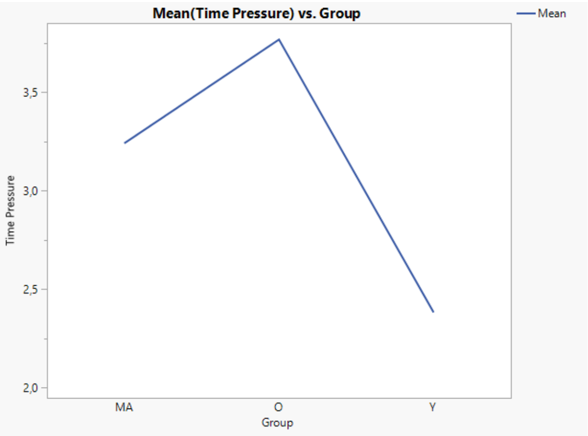


Figure 13: Time pressure (Group)

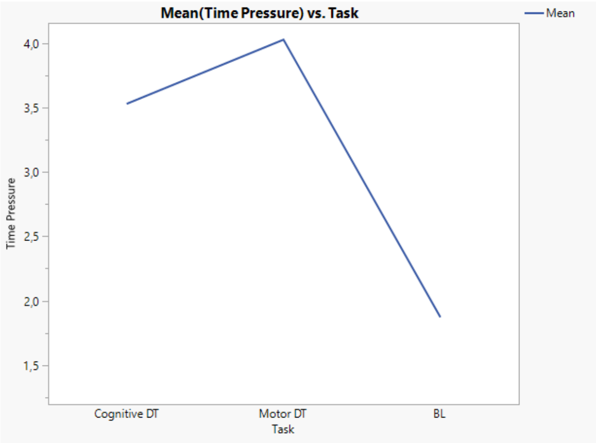


Figure 14: Time pressure (Task)

3.3.4 Performance

Significant effects were found between groups (p=0.0013) and tasks (p<0.0001), shown in figures 15 and 16. The younger group had a significantly higher subjective performance compared to the middle-aged (p=0.0004) and older group (p=0.0116). The motor DT scored a significantly lower subjective performance compared to the cognitive DT and BL (p<0.0001).

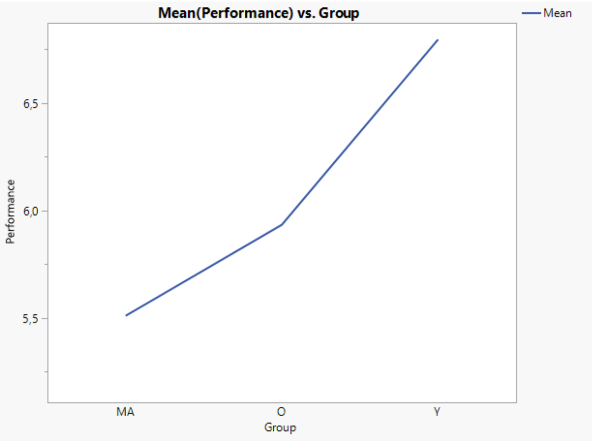


Figure 15: Performance (Group)

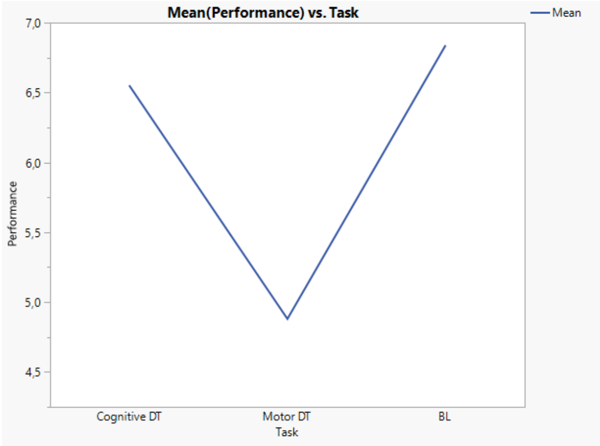


Figure 16: Performance (Task)

3.3.5 Overall load

Significant effects were found for groups (p=0.0017) and tasks (p<0.0001), shown in figures 17 and 18. The young group scored a significantly lower overall load compared to the middle-aged (p=0.0165) and older group (p=0.0005). The BL had a significantly lower overall load compared to both the cognitive and motor DT (p<0.0001).

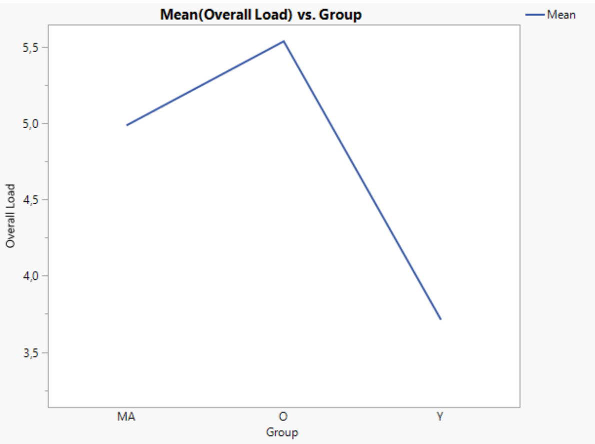


Figure 17: Overall load (Group)

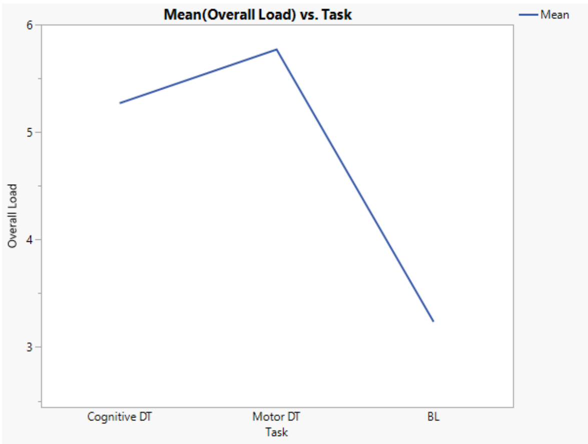


Figure 18: Overall load (Task)

3.3.6 Frustration

Significant effects were found for groups (p=0.0025) and tasks (p<0.0001), shown in figures 19 and 20. The young group showed significantly lower frustration than the middle-aged (p=0.0015) and older group (p=0.0047). For the BL, participants experienced less frustration than with the cognitive (p=0.0008) and motor DT (p<0.0001). Participants also experienced less frustration for the cognitive DT compared to the motor DT (p=0.0072).

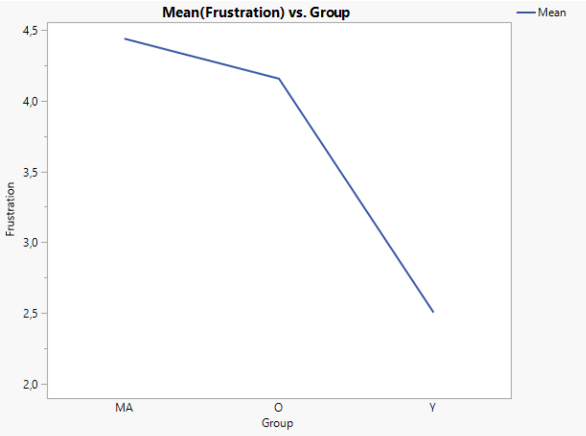


Figure 19: Frustration (Group)

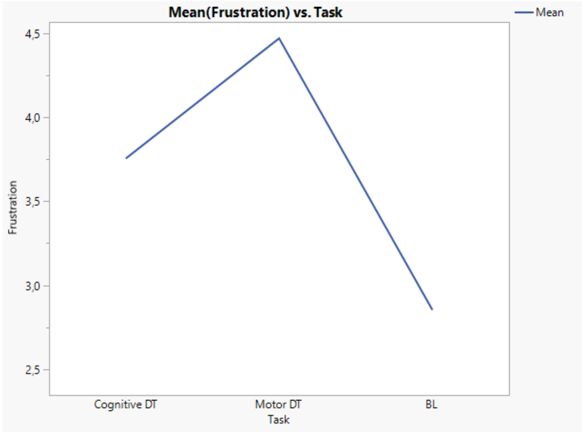


Figure 20: Frustration (Task)

4. Discussion

This study was performed to investigate to what extent DT's cause distraction when driving in different age groups. Knowing the effect of DT's and age on driving performance will help us find solutions to drive safer and cause less crashes. The main results of this study show the overall effects of age and the presence of DT's on driving performance. A deterioration in driving performance with increasing age was found in driving with and without DT's. This study also measured the performance of the motor and cognitive task without driving. Horrey, Lesch, and Garabet (2009) found that for cognitive DT's (the PASAT and a guessing task), the performance of the cognitive task without driving was significantly better than with driving. They also found no significant difference between young and older drivers, which is in contrast to this study, which found that younger drivers had a significantly better DT performance than older drivers. Stojan and Voelcker-Rehage (2021) concluded that every age group is vulnerable to DT's while driving. However, neurocognitive task demands seem to explain the age difference. They stated that older drivers may show a higher risk for accidents with the presence of visual-motor DT's when driving (e.g. use of a navigational system), while the younger group could be more distracted when talking to a passenger.

This study investigated the effect of motor and cognitive DT's on driving performance in three age groups. We included the PASAT as the cognitive DT. Thompson et al. also used the PASAT during driving, and these results showed lower speed and more safety errors in the older group compared to the middle-aged group. Holste, Yasen, Hill, and Christie (2016) explained that when performing a cognitive DT, motor cortex excitability and inhibition both increased. A greater inhibition of the motor cortex can explain the experience of motor deficits while performing a cognitive DT. These motor deficits were explained by a higher variability in force production. This could probably lead to the presence of more safety errors when driving. Walker, Eng, and Trick (2021) investigated the effect of three different DT's in younger drivers. They found that all types led to a significant decrease in driving performance, but this effect was not equal for all DT's. They found that for the motor DT's (texting and putting on a song via a touchscreen) led to significantly more decrease in driving performance compared to the cognitive DT (having a conversation with a hands free phone).

In our study we investigated the effects of age and DT's on the steering reversal rate (SSR), and found that on straight roads, older drivers showed a higher score compared to middle-aged drivers. McLean and Hoffmann (1975) investigated steering reversals as a measure of driving performance and difficulty of the steering task. They showed that an increased reversal rate can be explained as the difficulty to maintain an acceptable steering accuracy. We expected a higher SRR when performing a DT compared to BL. In all groups the cognitive DT led to the highest SSR score. However, the older drivers showed a lower SRR score during the motor DT condition compared to BL. For the middle-aged and young group no difference was found between these conditions. Since there are few studies that used SRR as a driving parameter, it is not clear why cognitive DT's lead to a higher SRR compared to BL and motor DT's. For the other primary outcomes, e.g. SDLP, HE and track, a clear difference between DT's was found. In general, the motor DT led to more distraction compared to the cognitive DT. In multiple studies the DT during driving consists of a cognitive DT e.g. Thompson et al. (2012) or is composed of a motor and a cognitive component e.g. Karthaus et al. (2020). Since there are very few studies that investigate the effect of a purely motor DT on driving performance, future research needs to be done to investigate the difference between the effects of cognitive and motor DT's.

In this study, the participants drove on straight road sections and curves. We expected that DT's would lead to a more deteriorating driving performance when driving on a curve compared to a straight road section. Vieira and Larocca (2018) showed that when the drivers were distracted, they didn't recognize the beginning of the curve at the same level as they did when they were fully engaged in the driving task. When participants got distracted by a cognitive test, they also drove at higher speed through the curve. When drivers were more aware of driving, their driving performance noticeably improved and they noticed the curves in advance to slow down. In this study the participants drove at a constant speed, thus they couldn't accelerate when distracted. However, we did find that participants showed a deteriorating driving performance in general when driving on curves.

This study also investigated the effect of DT's on subjective workload in different age groups. Overall, the subjective workload was higher for both DT's compared to the BL. Horrey et al. (2009) found the same results for the cognitive DT's. They also found no main age effect, which is in contrast to the results in this study, which show that overall, younger drivers experienced less workload. However, they did find a significant interaction effect showing that younger drivers found the PASAT-task more challenging than older drivers. No interaction effect for age and task was found in this study. Walker et al. (2021) found that the overall subjective driving performance, consisting of items such as distraction, driving challenge, difficulty with focus, and driving performance, was significantly more difficult for the two different motor DT's than for the cognitive DT.

This study shows several strengths. A total of 81 participants were included, which exceeded the minimum amount of n=30, which is needed for sufficient power. The participants were subdivided in three different age groups. Multiple studies included merely two age groups e.g. Chaparro et al. (2005) and Thompson et al. (2012) . Including a third age group led to the possibility to investigate the evolution of the driving performance by age more accurately. Further, the participants were pseudo-randomised for the DT conditions to avoid a learning effect. When driving in a simulator, simulator sickness (SS) is a common symptom, with older participants being more susceptible than younger participants (Brooks et al., 2010). Therefore participants were informed about the symptoms and these were monitored by the Simulator Sickness Questionnaire (SSQ). According to Balk et al. (2013), SS could be prevented by the following precautionary measures: screening for migraine headaches, a history of motion sickness and pregnancy; keeping a low temperature in the room; giving the participants time to slowly adjust to the simulator; and encouraging the participants to express possible feelings of discomfort. This study prevented SS by taking the SSQ after every driving task, so that the driving session could be stopped once a participant experienced early symptoms. Another strength is that a constant driving speed was used to eliminate slowing down as compensatory behaviour. At last, all test administrations were done by the same examiner, which ensured all participants were given instructions in the same manner.

This study also includes some limitations. Firstly, there could be a healthy user bias. Older people who can drive well might be more likely to participate in a driving study. Also, a majority of the older participants were recruited through social media, which might be a medium that is mostly used by older participants with good cognitive function. Furthermore, a confounding bias could be present, since not all characteristics are equal. The higher mileage of the young group can have a positive effect on their driving performance. Das, Ghasemzadeh, and Ahmed (2019) stated that lane keeping performance was better for drivers who drove more than 12 000 miles in the last year compared to drivers who drove less than 12 000 miles. Even though there were significant differences found for the MOCA and no statistical analysis was done for the Snellen test, this will have a minimal effect on the outcome measures since all participants met the inclusion criteria for these tests. Lastly, when driving in a simulator, there is no influence of bad weather or traffic. Additionally, the pedals were not used to regulate driving speed but to perform the motor DT. These situations are not representative of a real life driving situation.

A recommendation for future research is to perform this study in a real world environment, with the influence of weather and traffic conditions. Furthermore, a different type of motor DT can be used that is more representative to real driving, e.g. handling a dashboard. Future studies can also include a different type of cognitive DT than the PASAT, e.g. talking to a passenger. In Horrey et al. (2009), they compared a guessing DT with the PASAT. This guessing task resembles a conversation and leads to a poorer driving performance and more subjective workload compared to the PASAT task. Lastly, a fourth age group, such as a younger middle-aged group, can be included to give a broader view of the start of the decline in driving performance.

5. Conclusion

This study indicates that age and DT's have an overall effect on driving performance and subjective workload, with a deterioration with age in both outcome measures. A motor DT seems to have more effect on driving performance compared to the cognitive DT. Future research should further determine whether a motor DT is more distracting than a cognitive DT when driving in all age groups.

Appendix
Appendix A

Statistics

Table 1

*SDLP (Group*Task)*

Group	Task	- Group	- Task	P-value
MA	BL	MA	Cognitive DT	0.6465
MA	BL	MA	Motor DT	<0.0001
MA	BL	O	BL	0.0015
MA	BL	Y	BL	0.8763
MA	Cognitive DT	MA	Motor DT	0.0004
MA	Cognitive DT	O	Cognitive DT	0.0152
MA	Cognitive DT	Y	Cognitive DT	0.5588
MA	Motor DT	O	Motor DT	<0.0001
MA	Motor DT	Y	Motor DT	0.1451
O	BL	O	Cognitive DT	0.3506
O	BL	O	Motor DT	<0.0001
O	BL	Y	BL	0.0007
O	Cognitive DT	O	Motor DT	<0.0001
O	Cognitive DT	Y	Cognitive DT	0.0022
O	Motor DT	Y	Motor DT	<0.0001
Y	BL	Y	Cognitive DT	0.7704
Y	BL	Y	Motor DT	0.0692
Y	Cognitive DT	Y	Motor DT	0.0351

Table 2

*HE (Group*Task)*

Group	Task	-Group	-Task	P-value
MA	BL	MA	Cognitive DT	0.6733
MA	BL	MA	Motor DT	<0.0001
MA	BL	O	BL	0.0240
MA	BL	Y	BL	0.1072
MA	Cognitive DT	MA	Motor DT	<0.0001
MA	Cognitive DT	O	Cognitive DT	0.0427
MA	Cognitive DT	Y	Cognitive DT	0.0539
MA	Motor DT	O	Motor DT	<0.0001
MA	Motor DT	Y	Motor DT	<0.0001
O	BL	O	Cognitive DT	0.9948
O	BL	O	Motor DT	<0.0001
O	BL	Y	BL	0.0001
O	Cognitive DT	O	Motor DT	<0.0001
O	Cognitive DT	Y	Cognitive DT	<0.0001
O	Motor DT	Y	Motor DT	<0.0001
Y	BL	Y	Cognitive DT	0.8599
Y	BL	Y	Motor DT	0.0256
Y	Cognitive DT	Y	Motor DT	0.0161

Table 3

HE (Road)

Road	-Road	P-value
Curve	No Curve	<0.0001

Table 4

*SSR (Road*Group)*

Road	Group	-Road	-Group	P-value
Curve	MA	Curve	O	0.0121
Curve	MA	Curve	Y	0.0518
Curve	MA	No Curve	MA	0.7852
Curve	O	Curve	Y	0.5709
Curve	O	No Curve	O	0.0039
Curve	Y	No Curve	Y	0.0019
No Curve	MA	No Curve	O	0.0020
No Curve	MA	No Curve	Y	0.2467
No Curve	O	No Curve	Y	0.0447

Table 5

*SSR (Group*Task)*

Group	Task	-Group	-Task	P-value
MA	BL	MA	Cognitive DT	<0.0001
MA	BL	MA	Motor DT	0.0105
MA	BL	O	BL	0.0042
MA	BL	Y	BL	0.1415
MA	Cognitive DT	MA	Motor DT	<0.0001
MA	Cognitive DT	O	Cognitive DT	0.0008
MA	Cognitive DT	Y	Cognitive DT	0.2183
MA	Motor DT	O	Motor DT	0.0444
MA	Motor DT	Y	Motor DT	0.0624
O	BL	O	Cognitive DT	<0.0001
O	BL	O	Motor DT	<0.0001
O	BL	Y	BL	0.1486
O	Cognitive DT	O	Motor DT	<0.0001
O	Cognitive DT	Y	Cognitive DT	0.0270
O	Motor DT	Y	Motor DT	0.9031
Y	BL	Y	Cognitive DT	<0.0001
Y	BL	Y	Motor DT	0.1315
Y	Cognitive DT	Y	Motor DT	<0.0001

Table 6

*Track (Road*Task)*

Road	Task	-Road	-Task	P-value
Curve	BL	Curve	Cognitive DT	0.4892
Curve	BL	Curve	Motor DT	<0.0001
Curve	BL	No Curve	BL	0.0002
Curve	Cognitive DT	Curve	Motor DT	<0.0001
Curve	Cognitive DT	No curve	Cognitive DT	0.0027
Curve	Motor DT	No Curve	Motor DT	0.8360
No Curve	BL	No Curve	Cognitive DT	0.1573
No Curve	BL	No Curve	Motor DT	<0.0001
No Curve	Cognitive DT	No Curve	Motor DT	<0.0001

Table 7

*Track (Group*Task)*

Group	Task	-Group	-Task	P-value
MA	BL	MA	Cognitive DT	0.0141
MA	BL	MA	Motor DT	<0.0001
MA	BL	O	BL	0.8842
MA	BL	Y	BL	0.2872
MA	Cognitive DT	MA	Motor DT	<0.0001
MA	Cognitive DT	O	Cognitive DT	0.4520
MA	Cognitive DT	Y	Cognitive DT	0.0091
MA	Motor DT	O	Motor DT	0.9366
MA	Motor DT	Y	Motor DT	0.0002
O	BL	O	Cognitive DT	0.4480
O	BL	O	Motor DT	<0.0001
O	BL	Y	BL	0.2108
O	Cognitive DT	O	Motor DT	<0.0001
O	Cognitive DT	Y	Cognitive DT	0.0498
O	Motor DT	Y	Motor DT	0.0002
Y	BL	Y	Cognitive DT	0.4789
Y	BL	Y	Motor DT	<0.0001
Y	Cognitive DT	Y	Motor DT	<0.0001

Table 8

Percentage Cognitive (Group)

Group	-Group	P-value
MA	O	0.0427
MA	Y	0.2850
O	Y	0.0019

Table 9

Percentage Motor (Group)

Group	-Group	P-value
MA	O	0.1660
MA	Y	0.1488
O	Y	0.0043

Table 10

Mental load (Task)

Task	-Task	P-value
Cognitive DT	Motor DT	0.0407
Cognitive DT	BL	<0.0001
Motor DT	BL	<0.0001

Table 11

Physical load (Group)

Group	-Group	P-value
MA	O	0.8661
MA	Y	0.0030
O	Y	0.0012

Table 12

Physical load(Task)

Task	-Task	P-value
Cognitive DT	Motor DT	<0.0001
Cognitive DT	BL	0.0002
Motor DT	BL	<0.0001

Table 13

Time pressure (Group)

Group	-Group	P-value
MA	O	0.2904
MA	Y	0.0920
O	Y	0.0055

Table 14

Time pressure (Task)

Task	-Task	P-value
Cognitive DT	Motor DT	0.0226
Cognitive DT	BL	<0.0001
Motor DT	BL	<0.0001

Table 15

Subjective performance (Group)

Group	-Group	P-value
MA	O	0.2172
MA	Y	0.0004
O	Y	0.0116

Table 16

Subjective performance (Task)

Task	-Task	P-value
Cognitive DT	Motor DT	<0.0001
Cognitive DT	BL	0.2355
Motor DT	BL	<0.0001

Table 17

Overall load (Group)

Group	-Group	P-value
MA	O	0.2844
MA	Y	0.0165
O	Y	0.0005

Table 18

Overall load (Task)

Task	-Task	P-value
Cognitive DT	Motor DT	0.0498
Cognitive DT	BL	<0.0001
Motor DT	BL	<0.0001

Table 19

Frustration (Group)

Group	-Group	P-value
MA	O	0.6272
MA	Y	0.0015
O	Y	0.0047

Table 20

Frustration (Task)

Task	-Task	P-value
Cognitive DT	Motor DT	0.0072
Cognitive DT	BL	0.0008
Motor DT	BL	<0.0001

Appendix B

Verklaring op eer Laura Houtevels

UHASSELT

Verklaring op Eer

Ondergetekende, student aan de Universiteit Hasselt (UHasselt), faculteit Revalidatiewetenschappen aanvaardt de volgende voorwaarden en bepalingen van deze verklaring:

1. Ik ben ingeschreven als student aan de UHasselt in de opleiding Revalidatiewetenschappen & kinesitherapie, waarbij ik de kans krijg om in het kader van mijn opleiding mee te werken aan onderzoek van de faculteit Revalidatiewetenschappen aan de UHasselt. Dit onderzoek wordt beleid door mevrouw Siel Depestele en kadert binnen het opleidingsonderdeel wetenschappelijke stage/masterproef. Ik zal in het kader van dit onderzoek creaties, schetsen, ontwerpen, prototypes en/of onderzoeksresultaten tot stand brengen in het domein van Hersenonderzoek (hierna: "De Onderzoeksresultaten").

2. Bij de creatie van De Onderzoeksresultaten doe ik beroep op de achtergrondkennis, vertrouwelijke informatie[1], universitaire middelen en faciliteiten van UHasselt (hierna: de "Expertise").

3. Ik zal de Expertise, met inbegrip van vertrouwelijke informatie, uitsluitend aanwenden voor het uitvoeren van hogergenoemd onderzoek binnen UHasselt. Ik zal hierbij steeds de toepasselijke regelgeving, in het bijzonder de Algemene Verordening Gegevensbescherming (EU 2016-679), in acht nemen.

4. Ik zal de Expertise (i) voor geen enkele andere doelstelling gebruiken, en (ii) niet zonder voorafgaande schriftelijke toestemming van UHasselt op directe of indirecte wijze publiek maken.

5. Aangezien ik in het kader van mijn onderzoek beroep doe op de Expertise van de UHasselt, draag ik hierbij alle bestaande en toekomstige intellectuele eigendomsrechten op De Onderzoeksresultaten over aan de UHasselt. Deze overdracht omvat alle vormen van intellectuele eigendomsrechten, zoals onder meer – zonder daartoe beperkt te zijn – het auteursrecht, octrooirecht, merkenrecht, modellenrecht en knowhow. De overdracht geschiedt in de meest volledige omvang, voor de gehele wereld en voor de gehele beschermingsduur van de betrokken rechten.

6. In zoverre De Onderzoeksresultaten auteursrechtelijk beschermd zijn, omvat bovenstaande overdracht onder meer de volgende exploitatiewijzen, en dit steeds voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding:

   - het recht om De Onderzoeksresultaten vast te (laten) leggen door alle technieken en op alle dragers;
   - het recht om De Onderzoeksresultaten geheel of gedeeltelijk te (laten) reproduceren, openbaar te (laten) maken, uit te (laten) geven, te (laten) exploiteren en te (laten) verspreiden in eender welke vorm, in een onbeperkt aantal exemplaren;

---

[1] Vertrouwelijke informatie betekent alle informatie en data door de UHasselt meegedeeld aan de student voor de uitvoering van deze overeenkomst, inclusief alle persoonsgegevens in de zin van de Algemene Verordening Gegevensbescherming (EU 2016/679), met uitzondering van de informatie die (a) reeds algemeen bekend is; (b) reeds in het bezit was van de student voor de mededeling ervan door de UHasselt; (c) de student verkregen heeft van een derde zonder enige geheimhoudingsplicht; (d) de student onafhankelijk heeft ontwikkeld zonder gebruik te maken van de vertrouwelijke informatie van de UHasselt; (e) wettelijk of als gevolg van een rechterlijke beslissing moet worden bekendgemaakt, op voorwaarde dat de student de UHasselt hiervan schriftelijk en zo snel mogelijk op de hoogte brengt.

1

- het recht om De Onderzoeksresultaten te (laten) verspreiden en mee te (laten) delen aan het publiek door alle technieken met inbegrip van de kabel, de satelliet, het internet en alle vormen van computernetwerken;
- het recht De Onderzoeksresultaten geheel of gedeeltelijk te (laten) bewerken of te (laten) vertalen en het (laten) reproduceren van die bewerkingen of vertalingen;
- het recht De Onderzoeksresultaten te (laten) bewerken of (laten) wijzigen, onder meer door het reproduceren van bepaalde elementen door alle technieken en/of door het wijzigen van bepaalde parameters (zoals de kleuren en de afmetingen).

De overdracht van rechten voor deze exploitatiewijzen heeft ook betrekking op toekomstige onderzoeksresultaten tot stand gekomen tijdens het onderzoek aan UHasselt, eveneens voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding.

Ik behoud daarbij steeds het recht op naamvermelding als (mede)auteur van de betreffende Onderzoeksresultaten.

7. Ik zal alle onderzoeksdata, ideeën en uitvoeringen neerschrijven in een "laboratory notebook" en deze gegevens niet vrijgeven, tenzij met uitdrukkelijke toestemming van mijn UHasseltbegeleider mevrouw Siel Depestele.

8. Na de eindevaluatie van mijn onderzoek aan de UHasselt zal ik alle verkregen vertrouwelijke informatie, materialen, en kopieën daarvan, die nog in mijn bezit zouden zijn, aan UHasselt terugbezorgen.

Gelezen voor akkoord en goedgekeurd,

Naam: Laura Hockeels

Adres: Donkerstraat 30 2820 Rijmenam

Geboortedatum en -plaats : 27/05/1999 te Leuven

Datum: 26/05/2022

Handtekening:

Appendix C

Verklaring op eer Charlotte Dekeyser

UHASSELT

Verklaring op Eer

Ondergetekende, student aan de Universiteit Hasselt (UHasselt), faculteit Revalidatiewetenschappen aanvaardt de volgende voorwaarden en bepalingen van deze verklaring:

1. Ik ben ingeschreven als student aan de UHasselt in de opleiding Revalidatiewetenschappen & kinesitherapie, waarbij ik de kans krijg om in het kader van mijn opleiding mee te werken aan onderzoek van de faculteit Revalidatiewetenschappen aan de UHasselt. Dit onderzoek wordt beleid door mevrouw Siel Depestele en kadert binnen het opleidingsonderdeel wetenschappelijke stage/masterproef deel 2. Ik zal in het kader van dit onderzoek creaties, schetsen, ontwerpen, prototypes en/of onderzoeksresultaten tot stand brengen in het domein van Hersenonderzoek (hierna: "De Onderzoeksresultaten").

2. Bij de creatie van De Onderzoeksresultaten doe ik beroep op de achtergrondkennis, vertrouwelijke informatie[1], universitaire middelen en faciliteiten van UHasselt (hierna: de "Expertise").

3. Ik zal de Expertise, met inbegrip van vertrouwelijke informatie, uitsluitend aanwenden voor het uitvoeren van hogergenoemd onderzoek binnen UHasselt. Ik zal hierbij steeds de toepasselijke regelgeving, in het bijzonder de Algemene Verordening Gegevensbescherming (EU 2016-679), in acht nemen.

4. Ik zal de Expertise (i) voor geen enkele andere doelstelling gebruiken, en (ii) niet zonder voorafgaande schriftelijke toestemming van UHasselt op directe of indirecte wijze publiek maken.

5. Aangezien ik in het kader van mijn onderzoek beroep doe op de Expertise van de UHasselt, draag ik hierbij alle bestaande en toekomstige intellectuele eigendomsrechten op De Onderzoeksresultaten over aan de UHasselt. Deze overdracht omvat alle vormen van intellectuele eigendomsrechten, zoals onder meer – zonder daartoe beperkt te zijn – het auteursrecht, octrooirecht, merkenrecht, modellenrecht en knowhow. De overdracht geschiedt in de meest volledige omvang, voor de gehele wereld en voor de gehele beschermingsduur van de betrokken rechten.

6. In zoverre De Onderzoeksresultaten auteursrechtelijk beschermd zijn, omvat bovenstaande overdracht onder meer de volgende exploitatiewijzen, en dit steeds voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding:
   - het recht om De Onderzoeksresultaten vast te (laten) leggen door alle technieken en op alle dragers;
   - het recht om De Onderzoeksresultaten geheel of gedeeltelijk te (laten) reproduceren, openbaar te (laten) maken, uit te (laten) geven, te (laten) exploiteren en te (laten) verspreiden in eender welke vorm, in een onbeperkt aantal exemplaren;

[1] Vertrouwelijke informatie betekent alle informatie en data door de UHasselt meegedeeld aan de student voor de uitvoering van deze overeenkomst, inclusief alle persoonsgegevens in de zin van de Algemene Verordening Gegevensbescherming (EU 2016/679), met uitzondering van de informatie die (a) reeds algemeen bekend is; (b) reeds in het bezit was van de student voor de mededeling ervan door de UHasselt; (c) de student verkregen heeft van een derde zonder enige geheimhoudingsplicht; (d) de student onafhankelijk heeft ontwikkeld zonder gebruik te maken van de vertrouwelijke informatie van de UHasselt; (e) wettelijk of als gevolg van een rechterlijke beslissing moet worden bekendgemaakt, op voorwaarde dat de student de UHasselt hiervan schriftelijk en zo snel mogelijk op de hoogte brengt.

1

- het recht om De Onderzoeksresultaten te (laten) verspreiden en mee te (laten) delen aan het publiek door alle technieken met inbegrip van de kabel, de satelliet, het internet en alle vormen van computernetwerken;
- het recht De Onderzoeksresultaten geheel of gedeeltelijk te (laten) bewerken of te (laten) vertalen en het (laten) reproduceren van die bewerkingen of vertalingen;
- het recht De Onderzoeksresultaten te (laten) bewerken of (laten) wijzigen, onder meer door het reproduceren van bepaalde elementen door alle technieken en/of door het wijzigen van bepaalde parameters (zoals de kleuren en de afmetingen).

De overdracht van rechten voor deze exploitatiewijzen heeft ook betrekking op toekomstige onderzoeksresultaten tot stand gekomen tijdens het onderzoek aan UHasselt, eveneens voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding.

Ik behoud daarbij steeds het recht op naamvermelding als (mede)auteur van de betreffende Onderzoeksresultaten.

7. Ik zal alle onderzoeksdata, ideeën en uitvoeringen neerschrijven in een "laboratory notebook" en deze gegevens niet vrijgeven, tenzij met uitdrukkelijke toestemming van mijn UHasseltbegeleider mevrouw Siel Depestele.

8. Na de eindevaluatie van mijn onderzoek aan de UHasselt zal ik alle verkregen vertrouwelijke informatie, materialen, en kopieën daarvan, die nog in mijn bezit zouden zijn, aan UHasselt terugbezorgen.

Gelezen voor akkoord en goedgekeurd,

Naam: CHARLOTTE DEKEYSER

Adres: ELFJULISTRAAT 13 9000 GENT

Geboortedatum en -plaats : 09/10/1994 GENT

Datum: 29/05/2022

Handtekening: Dekeyser

Appendix D

Advies promotor Charlotte Dekeyser

Inschrijvingsformulier verdediging masterproef academiejaar 2021-2022,
Registration form jury Master's thesis academic year 2021-2022,

GEGEVENS STUDENT - *INFORMATION STUDENT*

Faculteit/School: **Faculteit Revalidatiewetenschappen**
Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1644851 Dekeyser Charlotte**
Student number + name

Opleiding/*Programme*: **2 ma revalid. & kine musc.**

INSTRUCTIES - *INSTRUCTIONS*

Neem onderstaande informatie grondig door.

Print dit document en vul het aan met DRUKLETTERS.

In tijden van van online onderwijs door COVID-19 verstuur je het document (scan of leesbare foto) ingevuld via mail naar je promotor. Je promotor bezorgt het aan de juiste dienst voor verdere afhandeling.

Vul luik A aan. Bezorg het formulier aan je promotoren voor de aanvullingen in luik B. Zorg dat het formulier ondertekend en gedateerd wordt door jezelf en je promotoren in luik D en dien het in bij de juiste dienst volgens de afspraken in jouw opleiding.
Zonder dit inschrijvingsformulier krijg je geen toegang tot upload/verdediging van je masterproef.

Please read the information below carefully.

Print this document and complete it by hand writing, using CAPITAL LETTERS.

In times of COVID-19 and during the online courses you send the document (scan or readable photo) by email to your supervisor. Your supervisor delivers the document to the appropriate department.

Fill out part A. Send the form to your supervisors for the additions in part B. Make sure that the form is signed and dated by yourself and your supervisors in part D and submit it to the appropriate department in accordance with the agreements in your study programme.
Without this registration form, you will not have access to the upload/defense of your master's thesis.

LUIK A - VERPLICHT - IN TE VULLEN DOOR DE STUDENT
PART A - MANDATORY - TO BE FILLED OUT BY THE STUDENT

Titel van Masterproef/*Title of Master's thesis:*

O behouden - *keep* THE EFFECT OF A COGNITIVE AND MOTOR DUAL TASK ON SIMULATED DRIVING PERFORMANCE FOR YOUNG, MIDDLE-AGED AND
O wijzigen - *change to:* OLDER DRIVERS.

UHvoorlev5 29/05/2022

/: NAMEN PROMOTOR EN COPROMOTOR

O behouden - *keep* PROMOTOR: PROF. DR. RAF MEESEN BEGELEIDER: DRA. SIEL DEPESTELE

O wijzigen - *change to:*

In geval van samenwerking tussen studenten, naam van de medestudent(en)/*In case of group work, name of fellow student(s):*

O behouden - *keep* HOUTEVELS LAURA

O wijzigen - *change to:*

LUIK B - VERPLICHT - IN TE VULLEN DOOR DE PROMOTOR(EN)
PART B - MANDATORY - TO BE FILLED OUT BY THE SUPERVISOR(S)

Wijziging gegevens masterproef in luik A/*Change information Master's thesis in part A:*

O goedgekeurd - *approved*

O goedgekeurd mits wijziging van - *approved if modification of:*

Scriptie/*Thesis:*

X openbaar (beschikbaar in de document server van de universiteit)- *public (available in document serv er of university)*

O vertrouwelijk (niet beschikbaar in de document server van de universiteit) - *confidential (not available in document server of university)*

Juryverdediging/*Jury Defense:*

De promotor(en) geeft (geven) de student(en) het niet-bindend advies om de bovenvermelde masterproef in de bovenvermelde periode/*The supervisor(s) give(s) the student(s) the non-binding advice:*

X te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

Ö de verdediging is openbaar/*in public*

O de verdediging is niet openbaar/*not in public*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK C - OPTIONEEL - IN TE VULLEN DOOR STUDENT, alleen als hij luik B wil overrulen
PART C - OPTIONAL - TO BE FILLED OUT BY THE STUDENT, only if he wants to overrule part B

In tegenstelling tot het niet-bindend advies van de promotor(en) wenst de student de bovenvermelde masterproef in de bovenvermelde periode/*In contrast to the non-binding advice put forward by the supervisor(s), the student wishes:*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

UHvoorlev5 29/05/2022

LUIK D - VERPLICHT - IN TE VULLEN DOOR DE STUDENT EN DE PROMOTOR(EN)
PART D - MANDATORY - TO BE FILLED OUT BY THE STUDENT AND THE SUPERVISOR(S)

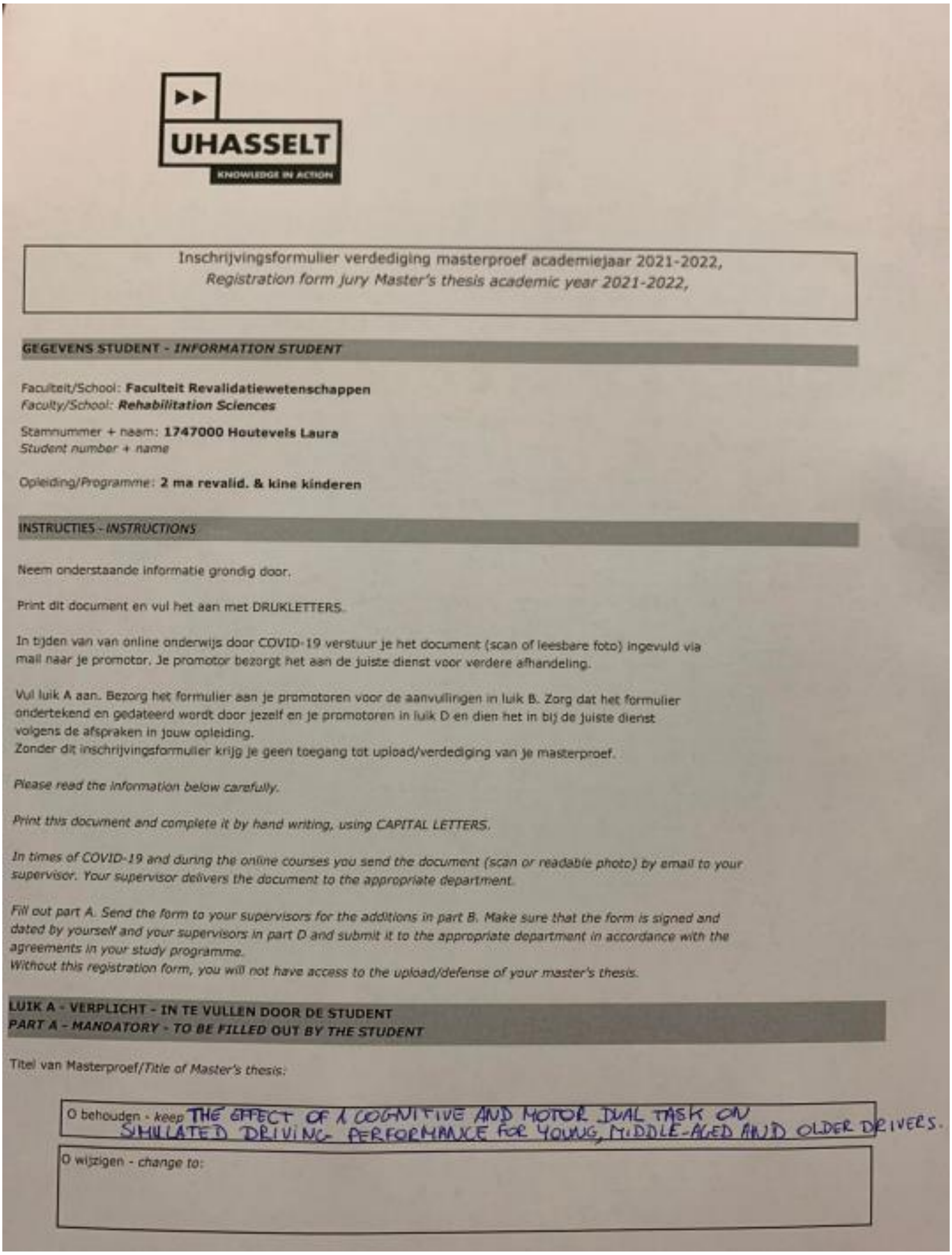
Datum en handtekening student(en)
Date and signature student(s)

29/05/2022

Datum en handtekening promotor(en)
Date and signature supervisor(s)

Appendix E

Advies promotor Laura Houtevels



UHASSELT
KNOWLEDGE IN ACTION

Inschrijvingsformulier verdediging masterproef academiejaar 2021-2022,
Registration form jury Master's thesis academic year 2021-2022,

GEGEVENS STUDENT - *INFORMATION STUDENT*

Faculteit/School: **Faculteit Revalidatiewetenschappen**
Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1747000 Houtevels Laura**
Student number + name

Opleiding/*Programme*: **2 ma revalid. & kine kinderen**

INSTRUCTIES - *INSTRUCTIONS*

Neem onderstaande informatie grondig door.

Print dit document en vul het aan met DRUKLETTERS.

In tijden van van online onderwijs door COVID-19 verstuur je het document (scan of leesbare foto) ingevuld via mail naar je promotor. Je promotor bezorgt het aan de juiste dienst voor verdere afhandeling.

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Fill out part A. Send the form to your supervisors for the additions in part B. Make sure that the form is signed and dated by yourself and your supervisors in part D and submit it to the appropriate department in accordance with the agreements in your study programme.
Without this registration form, you will not have access to the upload/defense of your master's thesis.

LUIK A - VERPLICHT - IN TE VULLEN DOOR DE STUDENT
PART A - MANDATORY - TO BE FILLED OUT BY THE STUDENT

Titel van Masterproef/*Title of Master's thesis:*

O behouden - *keep* THE EFFECT OF A COGNITIVE AND MOTOR DUAL TASK ON SIMULATED DRIVING PERFORMANCE FOR YOUNG, MIDDLE-AGED AND OLDER DRIVERS.

O wijzigen - *change to:*

/: NAMEN PROMOTOR EN COPROMOTOR

O behouden - *keep* PROF. DR. RAF MEESEN & MEVROUW drs. SIEL DEPESTELE

O wijzigen - *change to:*

In geval van samenwerking tussen studenten, naam van de medestudent(en)/*In case of group work, name of fellow student(s):*

O behouden - *keep*

O wijzigen - *change to:*

LUIK B - VERPLICHT - IN TE VULLEN DOOR DE PROMOTOR(EN)
PART B - MANDATORY - TO BE FILLED OUT BY THE SUPERVISOR(S)

Wijziging gegevens masterproef in luik A/*Change information Master's thesis in part A:*

O goedgekeurd - *approved*

O goedgekeurd mits wijziging van - *approved if modification of:*

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O vertrouwelijk (niet beschikbaar in de document server van de universiteit) - *confidential (not available in document server of university)*

Juryverdediging/*Jury Defense:*

De promotor(en) geeft (geven) de student(en) het niet-bindend advies om de bovenvermelde masterproef in de bovenvermelde periode/*The supervisor(s) give(s) the student(s) the non-binding advice:*

X te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

O de verdediging is openbaar/*in public*

O de verdediging is niet openbaar/*not in public*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK C - OPTIONEEL - IN TE VULLEN DOOR STUDENT, alleen als hij luik B wil overrulen
PART C - OPTIONAL - TO BE FILLED OUT BY THE STUDENT, only if he wants to overrule part B

In tegenstelling tot het niet-bindend advies van de promotor(en) wenst de student de bovenvermelde masterproef in de bovenvermelde periode/*In contrast to the non-binding advice put forward by the supervisor(s), the student wishes:*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK D - VERPLICHT - IN TE VULLEN DOOR DE STUDENT EN DE PROMOTOR(EN)
PART D - MANDATORY - TO BE FILLED OUT BY THE STUDENT AND THE SUPERVISOR(S)

Datum en handtekening student(en)
Date and signature student(s)

29/05/2022
Laura Houtevels

Datum en handtekening promotor(en)
Date and signature supervisor(s)

Appendix F

Inventarisatieformulier

www.uhasselt.be
Campus Hasselt | Martelarenlaan 42 | BE-3500 Hasselt
Campus Diepenbeek | Agoralaan gebouw D | BE-3590 Diepenbeek
T + 32(0)11 26 81 11 | E-mail: info@uhasselt.be

UHASSELT

INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
10/07/2021	Kennismaking met rijsimulator + mee assisteren (Laura Houtevels)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
13/7/2021	Kennismaking met rijsimulator + mee assisteren (Charlotte Dekeyser)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
9/10/2021	Mail naar promotor over begin masterproef	Promotor: Copromotor/Begeleider: Student(e): Student(e):
19/10/2021	Meeting met promotor in wetenschapspark - Overleg over verloop masterproef - Verkrijgen van alle gegevens via mail	Promotor: Copromotor/Begeleider: Student(e): Student(e):
4/12/2021	Mail naar promotor over: - Goedkeuring onderzoeksvragen - Gebruik van data en bijkomende vragen	Promotor: Copromotor/Begeleider: Student(e): Student(e):
24/02/2022	Online meeting met promotor	Promotor: Copromotor/Begeleider: Student(e): Student(e):
29/03/2022	Mail naar promotor omtrent vragen statistiek	Promotor: Copromotor/Begeleider: Student(e): Student(e):
4/04/2022	Mail naar promotor omtrent vragen statistiek	Promotor: Copromotor/Begeleider: Student(e): Student(e):
4/05/2022	Mail naar promotor omtrent feedback over de introductie	Promotor: Copromotor/Begeleider: Student(e): Student(e):
10/05/2022	Mail naar promotor omtrent - feedback introductie - vragen over statistiek	Promotor: Copromotor/Begeleider: Student(e): Student(e):
23/05/2022	Mail naar promotor omtrent vragen statistiek + vragenlijsten	Promotor: Copromotor/Begeleider: Student(e): Student(e):

Appendix G

Screening tools

Simulator Sickness Questionnaire

Persoonsidentificatie: .... Datum: ...../...../.........

SSQ

Omcirkel hoe sterk de volgende symptomen momenteel van toepassing zijn:

Onbehaaglijk gevoel	Niet	Een beetje	Behoorlijk	Sterk
Vermoeidheid	Niet	Een beetje	Behoorlijk	Sterk
Hoofdpijn	Niet	Een beetje	Behoorlijk	Sterk
Belasting van ogen	Niet	Een beetje	Behoorlijk	Sterk
Slaperig / suf gevoel	Niet	Een beetje	Behoorlijk	Sterk
Moeite met scherp zien	Niet	Een beetje	Behoorlijk	Sterk
De hoeveelheid speeksel neemt toe	Niet	Een beetje	Behoorlijk	Sterk
Zweten	Niet	Een beetje	Behoorlijk	Sterk
Misselijkheid	Niet	Een beetje	Behoorlijk	Sterk
Droge mond	Niet	Een beetje	Behoorlijk	Sterk
Moeite met concentreren	Niet	Een beetje	Behoorlijk	Sterk
Gevoel van 'vol hoofd'	Niet	Een beetje	Behoorlijk	Sterk
Wazig of troebel zien	Niet	Een beetje	Behoorlijk	Sterk
Duizeligheid met open ogen	Niet	Een beetje	Behoorlijk	Sterk
Duizeligheid met gesloten ogen	Niet	Een beetje	Behoorlijk	Sterk
Oriëntatieverlies	Niet	Een beetje	Behoorlijk	Sterk
Duidelijk de maag voelen	Niet	Een beetje	Behoorlijk	Sterk
Boeren (moeten) laten	Niet	Een beetje	Behoorlijk	Sterk

Bijzonderheden ____

____

Snellen test

Snellen Test www.provisu.ch

E	1	20/200
F P	2	20/100
T O Z	3	20/70
L P E D	4	20/50
P E C F D	5	20/40
E D F C Z P	6	20/30
F E L O P Z D	7	20/25
D E F P O T E C	8	20/20
L E F O D P C T	9	
F D P L T C E O	10	
P E Z O L C F T D	11	

In order to perform this test, please follow the instructions:

www.provisu.ch

Snellen Test

1. Print the test page in A4 standard format. Place yourself 2.8 meters (or 9 feet) away from the chart. If the test page is in another format, or if you wish to perform the test facing the screen, you will have to calculate the distance at which you must stand facing it, using the following formula: measure the height of the letter E (first line, 20/200) in millimeters. Then, divide the value of this measurement by 88. Finally, multiply it by 6. The result shows the distance at which you must be placed, in meters.
   E.g. (42/88) x 6 = 2.8 m

2. Test your visual acuity with correction (contact lenses or glasses).

3. Test one eye at a time. Start with the right eye, covering the left one without pressing on it. Then, examine the left eye by doing the opposite. If you are using correction glasses, you can cover the eye with a sheet of paper.

4. Read the letters from the largest to the smallest.

5. To make the examination easier and faster, another person can help you by showing the letters you must read among the lines of letters.

6. If you can read the letters of the 8^{th} line, your sight is optimal (visual acuity 20/20).

7. If your visual acuity is less than 20/20 or if you have doubts about your sight, visit your ophthalmologist.

NOTE: take the results as a recommendation. The results do not indicate a diagnosis whatsoever. Performing the test does not mean you should skip regular visits to your eye doctor, because you could easily miss signs that only a trained eye care practitioner would find.

Montreal Cognitive Assessment

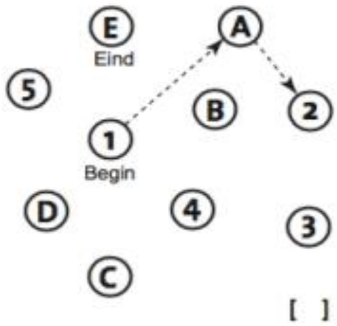
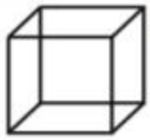
Nederlandse versie

MONTREAL COGNITIVE ASSESSMENT (MOCA)

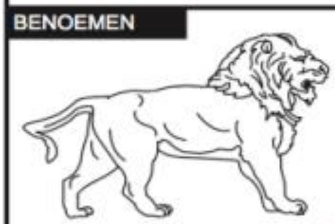
Jaren opleiding:

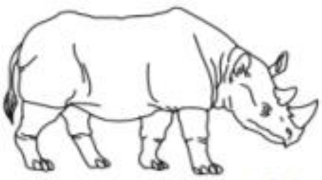
Code:

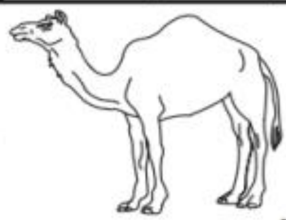
Datum:

VISUOSPATIEEL/EXECUTIEF			PUNTEN
 [ ]	 Kopieer de kubus [ ]	Teken een klok (tien over elf) (3 punten) [ ] Omtrek [ ] Cijfers [ ] Wijzers	__/5

BENOEMEN

 [ ]

 [ ]

 [ ]

__/3

GEHEUGEN Lees de woorden op, proefpersoon moet ze nazeggen. Neem 2 maal af. Laat ze na 5 min. opnieuw opnoemen.

	GEZICHT	FLUWEEL	KERK	MADELIEF	ROOD	Geen punten
1e afname						
2e afname						

AANDACHT	Lees de rij cijfers op (1 cijfer/sec). Proefpersoon moet ze in dezelfde volgorde nazeggen [ ] 2 1 8 5 4 Proefpersoon moet ze in omgekeerde volgorde nazeggen [ ] 7 4 2	__/2
	Lees de rij letters op. De proefpersoon moet bij iedere letter A met zijn hand op de tafel tikken. Geen punten bij ≥ 2 ft [ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B	__/1
	Serieel 7 aftrekken, beginnend bij 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65 4 of 5 goed: **3 pt** 2 of 3 goed: **2 pt** 1 goed: **1 pt** 0 goed: **0 pt**	__/3
TAAL	Zeg na: Ik weet alleen dat Jan vandaag geholpen zou worden. [ ] De kat verstopte zich altijd onder de bank als er honden in de kamer waren. [ ]	__/2
	Fluency: Noem binnen één minuut zo veel mogelijk woorden die beginnen met de letter D [ ] (N ≥ 11 woorden)	__/1
ABSTRACTIE	Overeenkomst tussen bijv. banaan en sinaasappel = fruit [ ] trein-fiets [ ] horloge-liniaal	__/2

UITGESTELDE RECALL	Woorden moeten herinnerd worden **zonder cue**	GEZICHT	FLUWEEL	KERK	MADELIEF	ROOD	Punten alleen voor recall zonder cue	__/5
		[ ]	[ ]	[ ]	[ ]	[ ]		
Optioneel	Categoriecue							
	Meerkeuzecue							

ORIËNTATIE	[ ] Datum [ ] Maand [ ] Jaar [ ] Dag [ ] Locatie [ ] Plaats	__/6

www.mocatest.org

Normaal ≥ 26 / 30

TOTAAL __/30

Tel er 1 pt bij op indien ≤ 12 jr opleiding

Subjective workload questionnaire

Vragenlijst subjectieve ervaring

Code: ....
Sessie:
Datum: ..../.........../.................
Taak:

- Mentale druk:

Hoeveel mentale en perceptuele activiteit (bv. Nadenken, beslissing nemen, rekenen, onthouden, kijken, zoeken, etc.) was noodzakelijk? Was de taak makkelijk of moeilijk, simpel of complex, veeleisend of mild?

- Fysieke druk:

Hoeveel fysieke activiteit (bv. Duwen, trekken, draaien, activeren, controleren, etc.) was noodzakelijk? Was de taak makkelijk of moeilijk, traag of bruusk, passief of inspannend, rustig of veeleisend?

- Tijdsdruk:

Hoeveel tijdsdruk ervaarde u door het tempo van de taak of de deeltaken? Was het tempo traag en ontspannend of snel en hectisch?

- Prestatie:

Hoe succesvol gelooft u dat u was in het bereiken van de doelen van de taak? Hoe tevreden was u met uw prestatie op de taak?

- Inspanning:

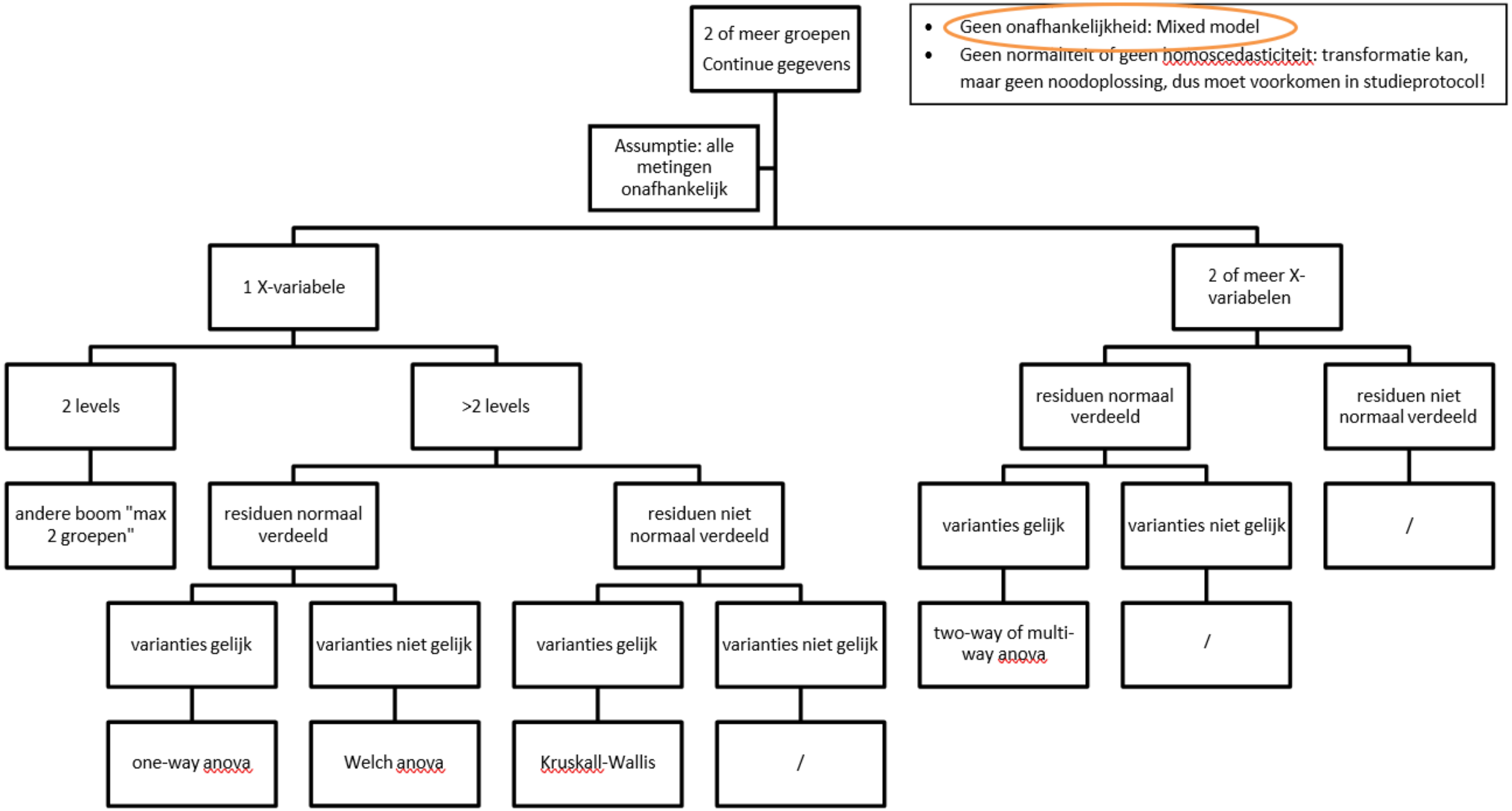
Hoe hard moest u werken (mentaal en fysiek) om dit prestatieniveau te behalen?

- Frustratie:

Hoe onzeker, ontmoedigd, geïrriteerd, gestresseerd en geërgerd versus zeker, tevreden, voldaan, ontspannen voelde u zich tijdens de taak?

Appendix H

Beslissingsboom statistiek



6. Reference list

Aksan, N. (2018). Comprehensive Assessments of the Effects of Auditory Cognitive Distractions on Driving Safety Across the Lifespan. In D. N. Cassenti (Ed.), *Advances in Human Factors in Simulation and Modeling* (Vol. 591, pp. 241-248).

Azzam D., R. Y. (2022). Snellen Chart. In *StatPearls [Internet]*. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK558961/

Balk, S. A., Bertola, M. A., & Inman, V. W. (2013). *Simulator sickness questionnaire: twenty years later.* Paper presented at the Proceedings of the Seventh International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design.

Bhojak, T., Jia, Y., Jacobsen, E., Snitz, B. E., Chang, C. H., & Ganguli, M. (2021). Driving Habits of Older Adults: A Population-based Study. *Alzheimer Dis Assoc Disord, 35*(3), 250-257. doi:10.1097/wad.0000000000000443

Brooks, J. O., Goodenough, R. R., Crisler, M. C., Klein, N. D., Alley, R. L., Koon, B. L., . . . Wills, R. F. (2010). Simulator sickness during driving simulation studies. *Accident analysis & prevention, 42*(3), 788-796.

Cantin, V., Lavallière, M., Simoneau, M., & Teasdale, N. (2009). Mental workload when driving in a simulator: effects of age and driving complexity. *Accid Anal Prev, 41*(4), 763-771. doi:10.1016/j.aap.2009.03.019

Chaparro, A., Wood, J. M., & Carberry, T. (2005). Effects of age and auditory and visual dual tasks on closed-road driving performance. *Optom Vis Sci, 82*(8), 747-754. doi:10.1097/01.opx.0000174724.74957.45

Das, A., Ghasemzadeh, A., & Ahmed, M. M. (2019). Analyzing the effect of fog weather conditions on driver lane-keeping performance using the SHRP2 naturalistic driving study data. *J Safety Res, 68*, 71-80. doi:10.1016/j.jsr.2018.12.015

Dingus, T. A., Guo, F., Lee, S., Antin, J. F., Perez, M., Buchanan-King, M., & Hankey, J. (2016). Driver crash risk factors and prevalence evaluation using naturalistic driving data. *Proc Natl Acad Sci U S A, 113*(10), 2636-2641. doi:10.1073/pnas.1513271113

Gronwall, D. M. (1977). Paced auditory serial-addition task: a measure of recovery from concussion. *Percept Mot Skills, 44*(2), 367-373. doi:10.2466/pms.1977.44.2.367

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In *Advances in psychology* (Vol. 52, pp. 139-183): Elsevier.

Holste, K. G., Yasen, A. L., Hill, M. J., & Christie, A. D. (2016). Motor Cortex Inhibition is Increased During a Secondary Cognitive Task. *Motor Control, 20*(4), 380-394. doi:10.1123/mc.2014-0047

Horrey, W. J., Lesch, M. F., & Garabet, A. (2009). Dissociation between driving performance and drivers' subjective estimates of performance and workload in dual-task conditions. *J Safety Res, 40*(1), 7-12. doi:10.1016/j.jsr.2008.10.011

Jackson, K. M., Shaw, T. H., & Helton, W. S. (2022). The effects of dual-task interference on visual search and verbal memory. *Ergonomics*, 1-11. doi:10.1080/00140139.2022.2061053

Kang, E. K., Shin, D., Yun, J. Y., Park, W., & Park, H. W. (2018). Investigating the interference pattern of dual tasks using serial decomposition. *Restor Neurol Neurosci, 36*(5), 639-646. doi:10.3233/rnn-180825

Karthaus, M., Wascher, E., Falkenstein, M., & Getzmann, S. (2020). The ability of young, middle-aged and older drivers to inhibit visual and auditory distraction in a driving simulator task. *Transportation Research Part F-Traffic Psychology and Behaviour, 68*, 272-284. doi:10.1016/j.trf.2019.11.007

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Mg, L. (1993). Simulator Sickness Questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology, 3*, 203-220.

Liu, Y. C., & Ou, Y. K. (2011). Effects of age and the use of hands-free cellular phones on driving behavior and task performance. *Traffic Inj Prev, 12*(6), 550-558. doi:10.1080/15389588.2011.607197

LLC, J. S. D. (2022). JMP Pro. Retrieved from https://www.jmp.com/en_be/software/predictive-analytics-software.html

Lyon, C., Brown, S., Vanlaar, W., & Robertson, R. (2021). Prevalence and trends of distracted driving in Canada. *J Safety Res, 76*, 118-126. doi:10.1016/j.jsr.2020.12.005

Makishita, H., & Matsunaga, K. (2008). Differences of drivers' reaction times according to age and mental workload. *Accident Analysis and Prevention, 40*(2), 567-575. doi:10.1016/j.aap.2007.08.012

Markkula, G., & Engström, J. (2006). *A steering wheel reversal rate metric for assessing effects of visual and cognitive secondary task load.* Paper presented at the Proceedings of the 13th ITS World Congress.

Marmeleira, J., Godinho, M., & Vogelaere, P. (2009). The potential role of physical activity on driving performance and safety among older adults. *European Review of Aging and Physical Activity, 6*, 29-38. doi:10.1007/s11556-009-0044-y

McEvoy, S. P., Stevenson, M. R., & Woodward, M. (2007). The prevalence of, and factors associated with, serious crashes involving a distracting activity. *Accid Anal Prev, 39*(3), 475-482. doi:10.1016/j.aap.2006.09.005

McLean, J. R., & Hoffmann, E. R. (1975). Steering Reversals as a Measure of Driver Performance and Steering Task Difficulty. *Human Factors, 17*(3), 248-256. doi:10.1177/001872087501700304

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., . . . Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc, 53*(4), 695-699. doi:10.1111/j.1532-5415.2005.53221.x

Pauzie, A. P., G. (1997). Subjective evaluation of the mental workload in the driving context. *Traffic & Transport Psychology: Theory and Application*, 173-182.

Periáñez, J. A., Lubrini, G., García-Gutiérrez, A., & Ríos-Lago, M. (2021). Construct Validity of the Stroop Color-Word Test: Influence of Speed of Visual Search, Verbal Fluency, Working Memory, Cognitive Flexibility, and Conflict Monitoring. *Arch Clin Neuropsychol, 36*(1), 99-111. doi:10.1093/arclin/acaa034

Schielzeth, H., Dingemanse, N. J., Nakagawa, S., Westneat, D. F., Allegue, H., Teplitsky, C., . . . Araya-Ajoy, Y. G. (2020). Robustness of linear mixed-effects models to violations of distributional assumptions. *Methods in Ecology and Evolution, 11*(9), 1141-1152.

Stojan, R., & Voelcker-Rehage, C. (2021). Neurophysiological correlates of age differences in driving behavior during concurrent subtask performance. *NeuroImage, 225*. doi:10.1016/j.neuroimage.2020.117492

Systems Technology, I. (2020). STISIM Drive. Retrieved from https://stisimdrive.com/

Thompson, K. R., Johnson, A. M., Emerson, J. L., Dawson, J. D., Boer, E. R., & Rizzo, M. (2012). Distracted driving in elderly and middle-aged drivers. *Accid Anal Prev, 45*(2), 711-717. doi:10.1016/j.aap.2011.09.040

UHasselt. (2022). Comité voor Medische Ethiek. Retrieved from https://www.uhasselt.be/Comite-voor-Medische-Ethiek#anch-d77-vergaderdata-samenstelling

Vieira, F. S., & Larocca, A. P. C. (2018). *Drivers distraction at curves under distraction task in static driving simulator.* Paper presented at the 18th International Conference Road Safety on Five Continents (RS5C 2018), Jeju Island, South Korea, May 16-18, 2018.

Walker, H. E. K., Eng, R. A., & Trick, L. M. (2021). Dual-task decrements in driving performance: The impact of task type, working memory, and the frequency of task performance. *Transportation Research Part F: Traffic Psychology and Behaviour, 79*, 185-204. doi:https://doi.org/10.1016/j.trf.2021.04.021

Wechsler, K., Drescher, U., Janouch, C., Haeger, M., Voelcker-Rehage, C., & Bock, O. (2018). Multitasking During Simulated Car Driving: A Comparison of Young and Older Persons. *Front Psychol, 9*, 910. doi:10.3389/fpsyg.2018.00910