On road driving assessment in Sweden

Results from the SafeMove project

Tania Dukic Willstrand, VTI
Helena Selander, Mobilitetscenter
Björn Peters, VTI
Thomas Broberg, VCC
On road driving assessment in Sweden
Results from the SafeMove project

Tania Dukic Willstrand
Helena Selander
Björn Peters
Thomas Broberg
Diarienummer: 2015/0010-8.2
Omslagsbilder: VTI/Hejdlösa Bilder
Tryck: LiU-Tryck, Linköping 2015
The on road study presented in this report is part of the SAFE MOVE project. The project is carried out in collaboration between VTI, Mobilitetscenter and Volvo Cars in Sweden and IFSTTAR, CNRS, INSERM, University of Bordeaux, University of Caen, University of Claude Bernard Lyon, OKTAL, Continental, Peugeot Citroen in France.

A similar study was performed in France where they also monitored in-vehicle data from the sensors installed such as speed, distance to other vehicle, etc.

The aim of the SAFE MOVE project is to increase knowledge and practice of safe mobility for older drivers by three complementary approaches in three subprojects:

- Sub-project 1: Survey assessment of older drivers and assessment with on-road tests and cognitive tests.
- Sub-project 2: Simulator based assessment and training of older drivers.
- Sub-project 3: Assistance systems for older drivers.

We thank Jan Andersson, research director at VTI, for his peer reviewing of the present report.

Göteborg October, 2015

*Tania Dukic Willstrand, VTI*

Acknowledgement

The SAFE MOVE project is supported by SAFER, Västra Götalandsregionen and Vinnova.
Quality review

Internal peer review was performed 13 October 2015 by Jan Andersson. First author, Tania Dukic Willstrand, has made alterations to the final manuscript of the report. The research director Jan Andersson examined and approved the report for publication 19 October 2015. The conclusions and recommendations expressed are the authors’/author’s and do not necessarily reflect VTI’s opinion as an authority.

Kvalitetsgranskning

Table of contents

Summary ............................................................................................................................................. 7
Sammanfattning .................................................................................................................................... 9
1. Background ...................................................................................................................................... 11
   1.1. Aim ............................................................................................................................................ 12
2. Method .......................................................................................................................................... 14
   2.1. Recruiting participants ............................................................................................................. 14
   2.2. Procedure ................................................................................................................................. 14
   2.3. Instrumentation and equipment ............................................................................................... 15
      2.3.1. Visual acuity ......................................................................................................................... 15
      2.3.2. Cognitive tests: UFOV and TMT ....................................................................................... 15
      2.3.3. Test vehicle ......................................................................................................................... 18
      2.3.4. On-road driving .................................................................................................................. 18
      2.3.5. In-depth interviews ............................................................................................................. 20
   2.4. Identification of estimators group ........................................................................................... 21
   2.5. Analysis ................................................................................................................................... 21
3. Results .......................................................................................................................................... 22
   3.1. Visual acuity and cognitive tests ............................................................................................. 22
      3.1.1. Visual acuity ....................................................................................................................... 22
      3.1.2. Useful Field Of View (UFOV) .......................................................................................... 22
      3.1.3. Trail Making Test (TMT) .................................................................................................... 22
      3.1.4. Fixed Random TMT (FR TMT) ......................................................................................... 22
   3.2. On-road driving ....................................................................................................................... 24
      3.2.1. The « B on road » expert assessment ................................................................................. 24
      3.2.2. Expert evaluation of the four traffic scenarios’ videos .......................................................... 25
      3.2.3. Self-assessment of the on-road driving based on interviews ............................................. 25
      3.2.4. Self-assessment of the four traffic scenario videos ............................................................. 26
      3.2.5. Post drive interviews .......................................................................................................... 26
   3.3. Correlation between cognitive tests and on-road driving behaviour ..................................... 28
   3.4. Categories of estimators ......................................................................................................... 28
4. Discussion ..................................................................................................................................... 30
5. Conclusions ................................................................................................................................... 33
References ......................................................................................................................................... 34
Summary

On road driving assessment in Sweden – Results from the SafeMove project

By Tania Dukic Willstrand (VTI), Helena Selander (Mobilitetscenter), Björn Peters (VTI) and Thomas Broberg (Volvo Cars)

The present on-road study is part of a major research project, Safe Mobility for Older Drivers – SAFE MOVE, carried out between Sweden and France in collaboration. At the beginning of the project, a cohort of 3,000 individuals were asked to fill-in a questionnaire regarding their health, their driving and mobility habits, particularly their use of cars.

From the cohort answers, 42 participants were recruited to perform an on-road driving. The aim was to identify the cognitive and driving ability of the drivers from the cohort and to match it with their own assessment of ability. We also aimed to identify difficulties encountered in traffic, both the type of behaviour and in which traffic scenarios they encountered the difficulties, as well as how the cognitive and driving ability were associated to estimators group.

The participants drove for 45 minutes in many different traffic environments. Two more people were present in the vehicle; a driving instructor (DI) who was responsible for safety (dual controls) and gave directions to follow throughout the route and an occupational therapist (OT) who observed and assessed the driving by means of the B On-road protocol. They also underwent a cognitive screening with the Useful Field of View test (UFOV), the Trail Making Test (TMT A & B) and the Computerized Fixed/Random Trail-Making Test (FR TMT).

Results showed that the behaviours which were found challenging for the drivers were related to speed adaptation, driving too fast for the situation, and lack of visual attention to other road users at intersections. All drivers had a visual acuity level required for holding a driving licence in Sweden. Results from the UFOV tests and from the TMT A&B showed a good processing speed and a shared attention. A correlation between the UFOV test and the number of errors in the B On-road test was found: the drivers having better performance in the test also had fewer errors in the on-road driving assessment. This correlation was also found with the gain of FR-TMT. When investigating the relation between the driving behaviour and whether the driver is over, under or adequate estimators, we found that the majority of the drivers are adequate estimators, the second biggest group is over estimators and the third one the under estimators. Results from the interview showed a relation where the adequate estimators showed higher acceptance to driving too fast for the situation whilst the over estimators did not see this problem with themselves but more with other drivers.

Recommendations for older drivers’ safe mobility to take into account for retraining sessions or developing driver assistance systems are speed adaptation and visual attention at roundabout and crossing. Within the SAFE MOVE project they will be introduced to training in the simulator and participating in demonstrations of assistance systems, both in-vehicle and in the simulator.
Sammanfattning

På-väg-utvärdering i Sverige – resultat från SafeMove-projektet

By Tania Dukic Willstrand (VTI), Helena Selander (Mobilitetscenter), Björn Peters (VTI) och Thomas Broberg (Volvo Cars)

På-väg studien är en del av ett forskningsprojektet Safe Mobility for Older Drivers (Safemove), som görs tillsammans med flera samarbetspartners i Frankrike. I början av projektet fick 3 000 äldre en enkät med frågor om hälsa, körvanor och framförallt bilanvändning. Utifrån dessa rekryterades 42 deltagare till en körtest på väg.

Målet var att identifiera förarnas kognitiva förmåga och körförmåga och matcha detta med deras bedömningar av den egna körförmågan. Vi hade också som mål att identifiera vad de äldre upplever som svårigheter i trafiken, både typ av beteende och i vilka trafiksituationer som svårigheter uppstår. Dessutom ville vi se hur sambandet såg ut mellan kör- och kognitiv förmåga och förarens egen bedömning av sin förmåga.

Deltagarna körde i 45 minuter i många olika trafikmiljöer. I bilen fanns en körinstruktör som var ansvarig för säkerheten (hade dubbla kontroller) och gav instruktioner att följa genom hela körningen. Dessutom observerade och bedömde en arbetsterapeut körningen med hjälp av ett B On-road protokoll. Förarna genomgick också en kognitiv screening med hjälp av följande test: the Useful Field of View test (UFOV), the Trail Making Test (TMT A & B) och the Computerized Fixed/Random Trail-Making Test (FR TMT).

Resultaten visar att de brister som fanns var relaterade till anpassning av farten, att köra för fort för situationen och brist på uppmärksamhet av andra trafikanter i korsningar. Alla förare hade den synförmåga som krävs för att ha körkort i Sverige. Resultaten från UFOV testerna och TMT A&B visade på god uppmärksamhet eller god kognitiv förmåga för deras ålder. En korrelation mellan UFOV testet och antalet fel i B On-road test hittades: de förare som hade bättre resultat i testet gjorde också färre fel under körningen på väg

När vi undersökte relationen mellan körbeteende och ifall föraren överskattade, underskattade eller hade rätt uppfattning om sin körförmåga, så fann vi att en majoritet av förarna bedömer sin körförmåga rätt. Näst största gruppen är de som överskattar sin förmåga och minst är gruppen som underskattar sin förmåga. Resultat från intervjun visade att de som har rätt i bedömningen av sin körförmåga visar en ödmjukare attityd i trafiken, medan överskattarna tycker att de beter sig bra i trafiken och att andra trafikanter ställer till problem.

Rekommendationer för säker mobilitet för äldre är att ge möjligheter till körtäning och/eller utveckling av förarstödssystem som stödjer anpassning av färd och uppmärksamhet i cirkulationsplatser och korsningar. Inom Safemove-projektet kommer deltagarna att introduceras för träning i simulator och ges möjlighet att delta i demonstrationer av förarstödssystem, både i fordon och i simulator.
1. Background

The SAFE MOVE project is based on the hypothesis that a correct estimation of one’s driving ability is important for safe driving (Figure 1). Some drivers, particularly women, relinquish driving early, and some others continue to drive in spite of cognitive and functional problems. It is necessary to help drivers to continue driving as long as it is safe and, at the same time, help them to improve their awareness of cognitive declines in order to self-regulate. Another hypothesis in the project is that awareness of cognitive declines may be correlated to awareness of driving ability and as a consequence to the degree of driving regulation. While some drivers have an over trust in their ability (also called “over estimators”) and will continue driving despite bad performance representing a risk in the traffic, other drivers have an under trust in their ability (also called “under estimators”) and will cease driving early even if their general health would allow them to keep driving.

![Diagram of SAFE MOVE project](image)

*Figure 1: Scope of the SAFE MOVE project.*

For many people, driving is an important activity and supports everyday activities that create meaning in life Persson (1993). The car can assist the older to be independent and take part in activities, especially for those living in more isolated rural areas. Cognitive tests, simulators, or on-road driving tests, or combinations of these, are often used to assess cognitive function and driving performance. On-road testing is often seen as gold standard to achieve a valid evaluation of driving ability. The goal is to observe and evaluate the persons’ actual driving behaviour. This requires a standard route and a
specific observation evaluation procedure. Along the route, the predefined driving behaviours are observed and assessed.

People aged 65 years and over are a rapidly growing segment of the driving population and are keeping their driving license longer (Lyman, Ferguson et al. 2002). Moreover, it becomes more common for women of all ages to be licence holders (Hakamies-Blomqvist and Wahlström 1998). However, despite good health and low crash rate women more often give up driving (Sirén, Hakamies-Blomqvist et al. 2004). Self-regulation of driving activities, including driving cessation is modulated by a number of other variables, such as age, functional impairment, socioeconomic status and particularly gender (Freund and Szinovacz 2002).

Driving is an important aspect of maintaining mobility and independence for older adults (Ball, Owsley et al. 1998). However, driving is also a complex task, requiring a range of visual, psychomotor and cognitive abilities (Anstey, Wood et al. 2005). Specific situations may also be more challenging, such as intersections, left-turns and merging. Declining cognitive functions can be an important contributor to driving problems encountered by older people, and are associated with increased crash risk (Anstey, Wood et al. 2005). Crash rates of older drivers are low when compared with the entire population of drivers. However, compared to a younger age class, the percentage of fatal accidents in urban areas tends to increase with increased age. Moreover, there is an increased risk of injury, hospitalization and death among older people following a crash.

There are often arguments that older drivers are aware of their impairments, e.g., declining cognitive, sensory and/or motor functions, and thereby self-regulate their driving (Charlton, Oxley et al. 2006). However, not all older drivers are able to self-regulate their driving behavior (Fildes 2008). Despite declining abilities and not applying any driving strategy, they may be an increased risk in traffic. Moreover, most drivers rate themselves better than the average driver (Marottoli and Richardson 1998).

Facing the challenge of our ageing society and the impact of mobility on health and well-being, it is necessary to help healthy drivers to continue driving as long as possible. In order to ensure a safe driving in the future for the older population, there is a need to improve their awareness of driving and cognitive troubles in order to help them self-regulate their driving. However, little is known on how awareness affects driving safety. The SAFE MOVE aims to fill in the gap of knowledge identified here.

1.1. Aim

The aim was to identify the cognitive and driving ability of the drivers from the cohort followed within the SAFE MOVE project and to match their abilities with their own assessment of ability. We are interested in identifying difficulties encountered in traffic, both the type of behaviour and during what scenario they encountered. Results will give input for the design of ADAS systems in vehicles and for training of older drivers. The on-road driving is also combined with cognitive tests and post-interviews. The aim of the on-road study can be summarised as followed:

- Identifying the traffic scenarios and behaviour that are specially difficult for older drivers
- Examine the relationship between cognitive and driving ability
- Investigate the relation between the driving behaviour and whether the drivers is over, under or adequate estimators
- Recommendations regarding scenarios to take into account in order to take preventive actions such as retraining sessions or developing driver assistance systems.
2. Method

2.1. Recruiting participants

For the entire SAFE MOVE project, participants from the cohort were recruited from the Swedish driving license register according to the following criteria:

- Born in 1941 or earlier (aged 70 years or more in the year 2011)
- Living in the county of Västra Götaland, Sweden
- Holder of a driving licence for category B, passenger car
- Still driving a car.

The total population meeting the first three of the above criteria comprised 143,389 individuals. A simple random sample of 3,000 was drawn. After one reminder, 1,962 questionnaires were returned (65%) and of these 1362 (70 % of the respondents) still drove a car. The results from this questionnaire have been reported in an internal project report within the Safe Move project (Henrikson, Levin et al. 2014). From the respondents, 177 persons had reported they were interested in further participation. For practical reasons, due to the broadness of the selected area (Figure 2), we contacted first people who lived within a 100 km radius from Göteborg. Thus, 42 persons were selected for the on-road driving, on a first come-first serve basis. As licensing authorities in Sweden require a certain visual acuity, i.e., 0.5 binocular, it was thereby an inclusion criteria. All 42 participants were examined and all fulfilled this requirement.

![Figure 2: Västra Götaland County, Sweden](image)

2.2. Procedure

The study took place at Mobilitetscenter in Göteborg and consisted of three parts beginning with visual and cognitive tests followed by an on-road driving and finally an in-depth interview. Prior to their participation the participants received written information about the study purpose and that participation would not affect on their driving licence. They also underwent a cognitive screening with the Useful Field of View test (UFOV), the Trail Making Test (TMT A & B), and the Computerized Fixed/Random Trail-Making Test (FR TMT).
For the on-road driving, all participants could choose to drive with either manual or automatic transmission, depending on what they were used to. The driving took approximately 40 minutes depending on the traffic conditions and two more people were present in the vehicle. The driving instructor (DI) had the safety responsibility (dual controls) and gave directions to follow throughout the route. The DI sat in the front passenger seat. The visual acuity and the cognitive tests were conducted by an occupational therapist (OT). Another OT collected the on-road data but was blinded to the cognitive test results. The OT sat in the back seat on the right side and was observing and assessing the driving.

Finally, each participant was interviewed regarding their driving habits and driving behaviour. They were also asked to score their performance in four specific situations recorded during the drive. At the end of the interview, the participants were offered feedback and/or advice on how to improve their driving performance or general questions about traffic rules. The feedback was given by the DI. The entire procedure lasted for less than 3 hours.

2.3. Instrumentation and equipment

2.3.1. Visual acuity

The visual acuity test is a measure of spatial resolution of the visual processing system which was tested by placing the participants 6 m in front of a whiteboard with black letters. The participants had to read the letters with right, left and both eyes, respectively.

2.3.2. Cognitive tests: UFOV and TMT

1. UFOV – Useful Field of View

The term “functional visual field” can be described as the visual field area which information can be acquired in a brief glance without eye or head movements. The UFOV (Useful Field of View) test requires both identification and localization of targets through subtests, which measure information processing, divided attention and selective attention. The UFOV is a PC-based visual and cognitive test and a measure of the visual field over which a person can process visual information (Figure 3). It comprises three subtests measured in milliseconds. The first subtest measures processing speed, the second measures processing speed for a divided attention task and the third subtest measures processing speed for a selective attention task (Edwards, Vance et al. 2005). A strong relationship between UFOV and driving performance has been confirmed in several studies (Myers, Ball et al. 2000, Duchek, Carr et al. 2003). The UFOV test has demonstrated a correlation with the incidence of crashes. A reduction of the UFOV scores has been associated with a history of at-fault crash involvement and has been found to predict future crash involvement (Owsley 1998).
In the first task, the person should identify an object (a car or a truck) presented in the centre of the screen, for shifting lengths of time (Figure 3). In the second part, the person should identify an object (car or truck) as before but also localise a simultaneously presented target (another car) in the periphery of the screen, which is alternately positioned at eight different points around the screen. The third task is similar to part two but the objects in the periphery are embedded in distracters (triangles) that make the task more difficult. The objects on the PC-screen are presented in milliseconds, range 16 to 500 ms. The score is representing the display speed in milliseconds, at which the participant can perform the tasks correctly, where lower scores indicating better performance (Edwards 2006).

2. TMT – Trail Making Test

The TMT (The Trail Making Test) is a cognitive test that measures visual search and sequencing, information processing speed, divided attention and flexibility (Reitan 1986). The test consists of two subtests, A & B. The first (A) task is to draw lines sequentially 25 encircled numbers on a paper. For task B, the person must alternate between numbers and letters (Figure 4). The score on each part represents the amount of time required to complete the task. Performance is affected by age and education but not by gender. Normative data are available for persons between 18-89 years of age (Tombaugh 2004).

Figure 3. UFOV (Useful Field of View) subtest 1.

Figure 4. TMT A (left) and TMT B (right).
3. Computerized Fixed/Random Trail-Making Test (FR TMT)

To measure the subjects’ ability of visual search, motor speed and mental flexibility, the subjects performed a computerized Trail-Making Test (FR (fixed/random) TMT) developed by Summala et al. (2008). The test was performed on a 23-inch touch screen (Figure 5).

![FR TMT set up.](Photo: SAFEMOVE)

The participants were instructed to mark numbers and letters in the same order as in the traditional TMT described above but in this case hit the targets (in the shape of circles with a width of 2.74 cm) by pressing a finger on to the screen. The test consisted of two parts: part A, targets with numbers, and part B, targets including both numbers and letters. Figure 6 shows the screen layouts for part A and part B, respectively.

![The screen layouts for the trail-making test part A (left) and part B (right). Only the first target (1) was marked with a blue circle.](Photo: SAFEMOVE)

The FR-TMT also includes a feature that allows the content in the circles to change. The circles had a fixed position on the screen but the content, i.e. numbers or letters, were either the same (fixed) or randomly changed after each hit (random). Hence, the test consisted of four sub-tests, which were all repeated once according to a predetermined order. Each sub-test consisted of 20 targets. Before the test started, the subjects trained on each sub-test with 12 targets. The random condition was included as means to measure visual search ability. Thus, an interesting measure to look at is how much they gain
in speed with fixed condition compared to the condition when the content in the circled change (i.e. (AR-AF)/AR and (BR-BF)/BR).

2.3.3. Test vehicle

The test vehicles used were two Volvo V-50, which is a common middle class car in Sweden. Except for the transmission type, manual versus automatic gear, both cars were identical. For safety reasons, they were equipped with dual controls and extra mirrors for the DI. The vehicles were also equipped with a remote camera to record specific driving situations.

2.3.4. On-road driving

The driving took approximately 40 minutes on a 20 km fixed route (Figure 7). Part of the route is normally used for driving assessments at Mobilitetscenter. The route has been developed and adapted throughout the years to meet a reasonable level of complexity when assessing driving behaviour. The route comprised a diversity of intersections, right and left turns, roundabouts and road signs. The route started with areas or roads with less traffic and low speed, to ensure the participants to have the opportunity to be familiarized with the vehicle. More demanding driving manoeuvres and environments were encountered later on the route, such as higher speeds, more traffic and more interactions with other road users.

![Figure 7: Route used for the on-road driving.](image)

The participants’ driving behaviour was recorded with a video camera inside the car at six specific locations. However, two of the locations were not considered useful for assessing driving performance, as the traffic conditions did not really allow driver controlled behaviour due to e.g. congestions. The OT and the DI scored the performance during these situations, on a 5-graded scale, where “1” indicated very bad behaviour and the traffic instructor had used the dual controls and 5 implied very good performance. After the drive, each participant was shown on a computer screen their own driving at the four traffic situations and scored their own behaviour on the same 5-graded scale. This was done to compare the expert assessment and the self-assessment of the driving to determine if a driver over, under or correctly assessed his/her own driving behaviour.
The first scenario was a left turn at an intersection with no traffic lights. A zebra crossing and tram tracks had to be passed when turning left, which required safe attention and planning (see Figure 8). A more demanding traffic environment was recorded and used for the second scenario including another left turn at a complex intersection with traffic lights. The situation required interaction with other road users, such as pedestrians, bicycles and other vehicles. After the left turn, the driver needed to find a specific direction (a traffic sign) and to change lane (see Figure 9). The third scenario was entering a motorway, the driver needed to accelerate and find a safe gap (see Figure 10). The forth scenario was a complex roundabout with restricted view where the driver had to drive straight ahead but required speed adaptation and attention to the left to be able to drive safely (see Figure 11).

![Figure 8: A left turn with no traffic lights (Google maps street view).](image1)

![Figure 9: Complex left turn with traffic lights, lane changing and following traffic signs (city centre).](image2)

![Figure 10: Entering a motorway.](image3)

![Figure 11: Straight ahead into a larger roundabout.](image4)

During the drive, each participant’s driving behaviour was scored by the OT using a scoring sheet, the B On-road (Figure 12). The “B On-road” (Behaviour On-Road) protocol is based on the Ryd On-road Assessment (ROA) developed for clinically fitness-to-drive assessments at Mobilitetscenter (Selander, Lee et al. 2011). The scoring sheet includes six main behaviour categories observed and scores (rows): manoeuvring, speed adjustment, attention, positioning, interaction in traffic and planning (Figure 12). Each behaviour category include 3-6 specific items, e.g., “Speed adjustment” includes “Too high”, “Too low” and “Irregular speed”. Driving behaviours are connected to specific traffic situations, in total six main traffic situations were included (columns), i.e., roundabout, crossing, traffic lights, straight road, speed bumps and other (merging, lane change and pedestrian crossing). Errors made are indicated by a mark “1”. The marks/scores may be summarized in order to reach an overall score. However, there were no cut-off for a pass or fail outcome.
2.3.5. In-depth interviews

A researcher conducted a 30 minutes long interview after the driving. The interview was semi-structured, i.e. an interview guide with predefined questions was designed but not necessarily followed in strict order. The main themes covered by the questions in the interviews were related to travel pattern, self-adaptation, and interaction in traffic, “me as a car driver” (the attitude towards driving a car, driving alone or driving/riding with others, if they have grandchildren and if they drive them) and questions regarding driving cessation were raised. The following questions were used as basis during the interview with a focus on getting clues as to their opinion of themselves as car drivers.

- Do you think it is fun to drive? What is fun in driving? (initial question for warm up)
- Which roads do you usually use? Are there are routes/sites that you try to avoid or avoid altogether today?
- How do you find that the traffic situation has changed in recent years? How do you think other road users are today compared to before? Pedestrians/cyclists? What do you think of them?
- Who usually drive if you go along with someone? You or your partner if in a relationship?
- If you drive with your wife/husband, does she/he comment on your driving?
- Do you drive/ride with other (older) people? How do you think you are driving compared to your friends?
- Do you have children? Do you have grandchildren? Do they ride with you?
- Are you satisfied with the car you drive today? Is something missing in it?
- There will be a day for all of us when we might have to stop driving, is it something you think about? How will life without a car be?

2.4. Identification of estimators group

In order to identify whether drivers are adequately evaluating their capacity, the driving or the cognitive capacity, we need to match an objective and a subjective assessment of their capacity to measure. By comparing the objective and subjective measure of the same capacity, we can analyse whether drivers are over, under or adequate estimators (see Table 1).

### Table 1: Matching between objective and subjective assessment of the ability to drive

<table>
<thead>
<tr>
<th>Own assessment of the ability to drive</th>
<th>Expert assessment of the ability to drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>good</td>
<td>good Adequate estimators Over estimators</td>
</tr>
<tr>
<td>poor</td>
<td>Under estimators Adequate estimators</td>
</tr>
</tbody>
</table>

2.5. Analysis

The B On-road protocol was used to get an objective measure of the drivers’ performance. The sum of all errors made during the driving was used to identify where the participants encountered difficulties. Four traffic situations were used to assess driving performance (own and expert) by comparing the 5-scale rates from the expert and the participants. A qualitative analysis of the interviews question responses formed the basis for determining how the drivers assessed themselves. Two researchers individually transcribed the interviews and did a content analysis based on the transcribed material. The questions used to determine the self-assessments were mainly under the area of “Me as a car driver”: Do you think you are a good driver compared to other people of your age? What do your husband/wife/children say about your driving skills? Do you experience changes in your driving performance compared to when you were younger? Do you experience difficult situations when you are driving today? A combination of answers in comparison to other drivers, as well as answers related to strengths and weaknesses in their own skills were used to classify how the drivers assessed themselves as good/poor as described in Table 1.
3. Results

Of the 42 participants, two did not complete the driving assessment due to unsafe driving behaviour and were excluded from further analysis. In total, 13 women with a mean age of 75.8 years (SD: 3.4), range 71 to 82 years old, and 27 men with a mean age of 75.5 years (SD: 3.1), range 71 to 85 years old participated in this study.

3.1. Visual acuity and cognitive tests

3.1.1. Visual acuity

The visual acuity of all drivers was above the level for holding a driver’s license in Sweden, i.e. 0.5 binocular. No drivers were excluded based on the visual acuity prior to the on-road assessment. The lowest visual acuity bilateral was 0.6 and the highest was 1.3.

3.1.2. Useful Field Of View (UFOV)

The results of the UFOV tests 1, 2 and 3 are presented both in Figure 13. As a group, they had a mean of 37 ms in subtest 1, 124 ms in subtest 2 and 253 ms in subtest 3. In subtest 3, a wide range of variability in the participants’ score was observed, ranging from 57 to 500. Twelve persons scored 300 ms or more in subtest 3 (lower scores indicating better performance). However, according to normative data a score of 320 is seen as a mean value for older persons (65+)(Edwards 2006).

3.1.3. Trail Making Test (TMT)

The results from the TMT A & B tests showed no divergence from what was to be expected according to the levels proposed by Tombaugh (2004). Except for one person, the group completed TMT A correctly and in order, i.e., 24p. As a group they had a mean of 35.9 s in Trail A and 80.5 s in Trail B. Eleven persons had some difficulties to alternate between numbers and letters, and made 1 or 2 errors. As a group their performance can be seen as slightly better than normative data (Tombaugh 2004).

3.1.4. Fixed Random TMT (FR TMT)

The distribution of mean time between correct pressed targets on the screen (IRI) for FR-TMT A and B (fixed and random) are shown in Figure 14 for 38 of the 40 participants. Due to technical problems, data is missing for two participants and one participant only completed part A of the test for the same reason. Note that FR-TMT data differs compared to traditional TMT data in that mean time between presses instead if total time is used.
Figure 14 Distribution of the results from the FR - TMT A and B (F= fixed, R=random). IRI = inter-response-intervals (time between two presses made by the subject).

In general, it can be seen that IRI is shortest for AF, followed by BF, AR and longest for BR as expected. We also find an age where mean IRI is increasing together with the age of the participants. Considering how well and fast drivers update the road view and other tasks, the visuospatial memory component should predict fluent and reliable time-sharing as well. It is the gain variable, computed as (AR-AF)/AR respectively (BR-BF)/BR, it means how much participants benefit from stable targets in relation to random targets. The distribution of these metrics can be seen in Figure 15. Analysis of early data show that this measure is sensitive in task A but not necessarily in B because the search is too difficult in the latter. Again, we find that the gain is correlated to age with longer gain value for older participants.
3.2. On-road driving

Of the 40 participants, 30 drivers used the manual transmission car (11 women and 19 men) and 10 used the automatic transmission car (2 women and 8 men). In total, due to unsafe behaviour the DI had to use the dual controls (brake pedal) for 6 participants (once each).

3.2.1. The « B on road » expert assessment

In total, attention and speed adaptation stands for half of the errors made during the on-road driving (Figure 16Figure 16). Speed adaptation’ errors are related to a too high speed in certain area such as high-density pedestrians’ areas or area with a limited field of vision. Concerning attentional errors, they are to a major extend related to a lack of attention to road signs (i.e. speed limit signs). The third behaviour contributing to the number of error is manoeuvring. Those errors are in majority related to changing gear. The majority of our sample chose to drive manual gear and they were in majority female drivers.

Figure 16: Distribution of mean number of errors per behavioural category during the on-road driving.

Figure 17 shows a distribution of the number of errors per road scenarios. Majority of the errors occurred at intersection and roundabout. Intersections’ errors are related to a lack of attention of other
road users coming from the right. For the roundabout, the errors are related to lack of attention to the left, which is a conflict with another road user present in the roundabout and coming from the left and the driver fails to notice the vehicle coming or judge him/her-self to have enough time to drive before.

![Mean number of errors per road scenario](image)

**Figure 17: Distribution of mean number of errors per road scenarios during the on-road driving.**

The number of errors is correlated to gender and age: the older the more errors and number of errors for women is higher than for men ($t=-3.385$; $p<0.05$). In average, women had 32 errors by driving whether men had 20 errors per driving. The larger differences were found for manoeuvre ($t=-5.196$; $p<0.01$), attention ($t=2.475$; $p<0.05$) and position behaviour ($t=-2.469$; $p<0.05$). The choice of transmission, automat versus manual, does not seem to have an effect on the number of errors at B On-road apart from the manoeuvring errors which are much larger for manual driving comparing to automat driving.

### 3.2.2. Expert evaluation of the four traffic scenarios’ videos

Due to technical problems, two participants were not rated due to missing videos. Further results include 38 participants. The DI evaluated the participants on the four specific traffic scenarios during the on-road driving (Table 2). They used a 5-points scale to evaluate the performance at these specific traffic scenarios.

**Table 2: Mean values of the expert rate from the DI for the video of the four scenarios.**

<table>
<thead>
<tr>
<th>Traffic scenarios</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>4.3</td>
<td>3.9</td>
<td>3.9</td>
<td>3.9</td>
</tr>
</tbody>
</table>

### 3.2.3. Self-assessment of the on-road driving based on interviews

The self-assessment of the on-road driving by the participants is based on the interview results. Listening to the interviews, a judgement on whether the participants assessed themselves as good driver or not was done. The answer to the questions used to do this judgement were primarily “Do you think you are a good driver?” and “what would your partner and friends say about your driving?” Thus all interview material was used to give a representative picture on whether the drivers assessed
themselves as good or poor drivers. In total, 38 participants assessed themselves as good drivers while two participants assessed themselves as poor drivers. A large part of the participants perceiving themselves as good drivers expressed it in the following way:

“I’m driving more calmly nowadays and slower”
“I get positive feedback from my partners and passengers in the car”
“I drive quite well”.
“I’m a good driver; I have not been involved in a traffic accident since I took my driving licence”.

A part of the participants justify themselves as good drivers by a lack of accident involvement; since they have not been involved in accidents then it must mean that they are good drivers. Many people also said that they get positive feedback from partners, family and friends. They are popular between pairs, many people wants to get a ride.

For the two participants self-evaluated as poor performers, one tells about how difficult it is today to drive due to various problems with her vision and also with all changes in the traffic such as higher speed and higher concentration of vehicles.

3.2.4. Self-assessment of the four traffic scenario videos
The participants rated their performance during the on-road driving for four specific scenarios. They used a 5-points scale to evaluate the performance at these specific traffic scenarios.

<table>
<thead>
<tr>
<th>Traffic scenarios</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>4,14</td>
<td>4,25</td>
<td>4,33</td>
<td>4,29</td>
</tr>
</tbody>
</table>

3.2.5. Post drive interviews
The results of the post drive interviews following the on-road driving assessment were the following based on themes selected from the semi-structured interview:

- Travel pattern
Most of the participants used their car on a regular basis for activities such as going to the grocery store, shopping and running errands and for some this was the only option based on their living and on the lack of suitable public transportation. The car was used for trips to social activities, hobbies or just for getting out for a view. Visits to family and friends were also common reasons for using a car and quite a few participants own summer cottages in the countryside requiring travel by car. Many participants mentioned using public transportation going into the city to avoid problems with parking as well as the congestion tax to enter Gothenburg.

- Self-adaptation
The participants mentioned that they avoided certain situations such as driving in the dark, often in combination with rain and weather leading to poor visibility or in rush hour. They also claimed that
they are more calm behind the wheel nowadays, that their driving style is more careful and calm, and that they are not in such a hurry any more. Many participants gave up driving abroad due to lack of confidence and because they are concerned about being involved in an accident abroad as that could become an awkward situation to deal with.

- Interaction in traffic
A majority of the participants complained about other road users not following traffic rules, driving too fast or close including young and old drivers, pedestrians, cyclists. Examples of annoyances were keeping too short distance to other vehicles or not indicating before changing lane or turning. Cyclists were mentioned as riding too fast when crossing roads. All participants perceived the road traffic to be much more intense, and to a certain degree more aggressive than in the past although the roads and infrastructure are by many believed to be better.

- Me as a car driver
A majority of the participants associate driving as a positive experience and they still enjoy driving a lot while few said that it is not fun anymore compared to how it used to be. Of the ones enjoying driving, the main reason was the feeling of freedom by being able to go where and when you want. The ones not enjoying it often related it as being a stressful situation.

Many of the participants admitted driving above the speed limit from time to time but saw nothing wrong with that as they believe most drivers to do the same and it is just following the traffic flow. Still some drivers felt confident in driving in their own pace, “if they are in a hurry needing to pass there may be a reason that I don’t know”.

Some drivers stated that they drive more calmly now and pointed out that they drive slightly slower today. When driving on motorways they keep in the right lane to avoid having to overtake slower moving traffic.

The majority of the drivers take passengers including their spouse or grandchildren and they are passengers from time to time themselves. A gender difference was observed among participants living in a relationship where the man was generally the driver. We asked questions regarding whether they received comments from their passengers, and many had indeed received comments from relatives and spouses related to speed (being too fast or too slow) to attention to other vehicles and manoeuvring (clutch and gears). We also asked what a third person (relative, spouse or friend) would say about their driving. The majority of the answers followed reflected the comments usually made by their passengers however in general the participants believed that any feedback by a third person would be positive.

- Driving cessation
Overall, the awareness that one day they would have to stop driving was high amongst the participants. The majority believed declining visual capacity, general health issues or a medical state such as dementia or stroke would be the leading reason for giving up driving. “When my children or friends tell me to stop” was also mentioned as a reason by some whilst only one mentioned they would stop once the doctor tells me it is time. A large difference by gender was found in response to the consequence of not being able to drive any more. Women showed a higher degree of acceptance while men were more negative and envisaged restrictions to their activities and hobbies. Having public transportation as the only option was perceived as a limitation. This was especially a concern for participants living in rural areas.
Feedback from the driving instructor

The interviews ended by offering participants feedback from the driving instructor and all but one participant accepted. The most common feedback provided was on speed adaptation and attention at intersections. Some participants easily accepted the feedback and expressed concern about the issues raised, whilst others were showing less interest by leading the feedback into a discussion of other aspects or even arguing as to the feedback. Many questions regarding traffic rules were asked often related to new signs and how to use the indicator specifically in roundabouts.

3.3. Correlation between cognitive tests and on-road driving behaviour

When it comes to the correlation between cognitive tests and on-road data, we find a number of correlations that are significant:

- UFOV 3 and B On-road
- Gain of FR-TMT and B On-road.

This means that participants having the higher number of errors during the on-road driving are the ones who are slower in general, a slower processing speed for a divided attention task and for a selective attention task.

3.4. Categories of estimators

According to their answers to 22 questions which were selected from the questionnaire in Sp1 (Henrikson, Levin et al. 2014), we could identify: 10 under estimators, 15 adequate estimators and 15 over estimators. No difference in age or gender was found between the three groups. Looking at the on-road data by dividing drivers into estimator’s group, we could not find any significant relations regarding neither their cognitive capacity nor the driving capacity.

Here follows a number of tables (Table 4,Table 5,Table 6) where a match between expert versus own assessment is presented. For each table, expert assessments and own assessment have been assessed and shared in two groups, good and poor ability. For the B On-road, the cut-off point was defined as the median value of the number of errors. For the video evaluation and the questionnaire, the cut off was 3 and lower rate defining the poor group and 4-5 defining the good group. For the interview, a qualitative judgement was done by two researchers to decide whether the participants evaluated themselves as good or poor drivers.

Table 4: Categories of estimators according to expert assessment of the driving ability with B On-road and own assessment of the driving ability by interview.

<table>
<thead>
<tr>
<th>Own assessment of the ability to drive by interview</th>
<th>Expert assessment of the driving ability with B On-road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>Good 22 correct estimators 15 over estimators</td>
</tr>
<tr>
<td>poor</td>
<td>1 under estimator 1 correct estimator</td>
</tr>
</tbody>
</table>

Table 5

Table 6
Table 5: Categories of estimators according to expert assessment of the driving ability by video evaluation and own assessment of the driving ability by question 70 from the questionnaire from the cohort study in SAFE MOVE.

<table>
<thead>
<tr>
<th>Own assessment of the driving ability by question 70 from the questionnaire</th>
<th>Expert assessment of the driving ability by video evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>19 correct estimators 10 over estimators</td>
</tr>
<tr>
<td>poor</td>
<td>7 under estimators 2 correct estimators</td>
</tr>
</tbody>
</table>

Table 6: Categories of estimators according to expert assessment of the driving ability by video evaluation and own assessment of the driving ability by video evaluation.

<table>
<thead>
<tr>
<th>Own assessment of the driving ability by video evaluation</th>
<th>Expert assessment of the driving ability by video evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>23 correct estimators 8 over estimators</td>
</tr>
<tr>
<td>poor</td>
<td>2 under estimators 4 correct estimators</td>
</tr>
</tbody>
</table>

Correlation between the video evaluation from the DI and the participants was 0.01. A high evaluation of the DI was also judged as high from the participants themselves.

Results from the correlation between expert and own assessment indicate that based on individual basis, drivers tend to assess themselves differently based on the way the question are asked or based on the methods used.
4. Discussion

One of the aims of this on-road driving study was to assess the drivers from the previous cohort study on their cognitive and driving ability (Henrikson, Levin et al. 2014). The aim was to identify difficulties encountered in real traffic both in relation to the type of behaviour and in the type of scenario they occurred. One of the behaviours which was found challenging for the drivers in the study was related to speed adaptation, driving too fast for the situation. This was similar to the findings in previous on-road studies using a similar route and assessment protocol (Selander, Bolin et al. 2012, Broberg and Dukic Willstrand 2014).

An addition in this study was the fact that attention errors to typically speed limit signs occurred to a large extent. How and if this is affecting the number of errors in relation to speed adaptation could be discussed. Speed adaptation problems were found in areas with many pedestrians and situations where the possible visual attention to other road users was limited. Other difficulties where related to visual attention to other road users in roundabout and intersection scenarios specifically to other road users with right of way. Again this was similar to findings in previous studies (Braitman, Kirley et al. 2007, Broberg and Dukic Willstrand 2014).

Braitman et al. (2007) found that the oldest drivers of their cohort aged 80 or older predominately made errors failing to detect other vehicles whilst the drivers aged 70-79 made more evaluation errors seeing other vehicles but misjudging their time for action. The number of errors in the on-road driving assessment was found to increase significantly with age, the older the more errors even though no specific analysis as to difference in type of error was made. So in summary difficulties with attention in intersections is also an area to address in terms of support for the elderly drivers as well as helping drivers to adapt their speed to the situation specifically in traffic scenarios involving many other road users and specifically vulnerable road-users.

The main effect in errors related to the choice of automatic versus manual transmission seems to be more to manoeuvre aspects with gearshift than with behaviours and traffic scenario. Caution as to drawing conclusions from this is however recommended as a direct influence of errors in specific scenarios, relation/causation between errors were not identified. Besides there are other studies indicating that using automatic transmission makes the drive more comfortable freeing up time for a more active and safe driving (Selander, Bolin et al. 2012).

Another interesting finding is the difference in number of errors between the male and female participants. This could not be explained neither by the use of automatic versus manual transmission nor by age. However, this might be attributed to the fact that the women in the study drive less having a shorter weekly mileage. The men drive 273 km/week in average whilst the women drive about 93 km/week (t=2,4; p<0,05). This difference is also found in number of trips per week where men tend to use their car more often than women. The results points further to the importance of practise and training to keep up the driving skill at higher age. Moreover, this stresses the need for more information to older women about the importance to stay active as a driver, for instance by sharing the driving with their partner if possible. If not then the risk is that when older women lose their spouse or partner their mobility is highly affected reducing out of home activities and quality of life which in turn may negatively affect their health and wellbeing (Marottoli, de Leon et al. 1997, Marottoli, Mendes de Leon et al. 2000, Oxley and Whelan 2008). Even though there are countermeasures such as refreshing courses at driving schools to help this group of women to stay mobile more work is required to make women aware of the necessity to stay active as a driver with increasing age.

Besides the on-road assessment, using the B-on road protocol an additional expert evaluation of 4 different scenarios was evaluated. The scores were generally high with a mean around 4 on a 5 grade scale. This was similar looking at the self-assessment made by the drivers of these situations. The high correlation seen between the expert- and self-assessment was likely due to the narrow scale used, 1-5,
where 3-5 was mostly used in all evaluations. Thus, if a wider scale had been used the results may have turned out more different.

The post drive interviews showed the need for individual mobility by car for both practical trips, so called primary mobility needs, i.e. access shops, services and appointments, and social trips - secondary mobility needs, i.e. independence, control, roles (Musselwhite and Haddad 2007). Also the interviews revealed the tertiary mobility need as defined by Musselwhite and Haddad (2007) that of just taking the car to get out for a view. The travel pattern of the participants was also in line with the earlier findings by Hjorthol et al. (2010) that as the need for commuting to work disappear, the need for other trips of practical, social or leisure nature may persist or even increase being a senior citizen. The awareness that one day one must give up driving was high within the group but at the same time a gender difference was seen were the male participants to higher degree envisaged negative restrictions to their secondary mobility needs specifically limiting their activities and hobbies. More so, for the drivers in the group who enjoyed driving the feeling of freedom and independence being able to go where and when you want was given as the reason for driving a car. All this further emphasises the importance of individual mobility as pointed out by Marottoli et al. (2000) as well as Oxley and Whelan (2008).

In the interviews many participants admitted to driving over the speed limit from time to time even though many mentioned that they believe to have adapted their driving more calm and slower now compared to when they were younger. However, awareness of the relevance of adapting speed to the situation was low based on the individual interviews keeping in mind that the error most common being that driving too fast for the situation.

It should be highlighted that even if many drivers mentioned adaptation such as avoiding driving in certain situations like rain and dark or avoid certain roads or places, maybe one of the most important adaptation in every day driving in urban areas, that of speed may not be fully implemented in the strategies of these older drivers. In addition, a difference in attitude could be seen based on the interviews between drivers estimating their ability as drivers well compared to those over estimating their ability in relation to their actual driving performance. The adequate estimators showing higher acceptance to the fact of driving too fast for the situation whilst the over estimators did not see this problem with themselves but more with other drivers. It is believed to be an important aspect both in relation to possible training for older drivers as well as in design of driver assist technologies. Similar trends where found regarding feedback from a third person on driving performance.

When it comes to the relationship between cognitive and driving ability comparing with self-assessment of ability, different methodologies were tried in order to identify which estimator category the drivers belong to, adequate, over or under estimator. Three different ways of matching ability and self-assessment were explored. One comparing expert assessment using the B on-road to self-assessment based on in-depth interviews, one comparing expert assessment by video evaluation with self-assessment using answer in the questionnaire and finally with expert assessment and self-assessment based on video evaluation. Different results of the number of drivers belonging to the different driver categories were found using the different methods. The majority of drivers in the group was found in the adequate estimator category, found to drive well, followed by the over estimator category using all three methods. The number of drivers belonging to the under estimating category and adequate estimators driving poorly were very few using all three methods. One explanation to this may be that the participants had joined the study on a voluntary basis and if you are a driver who drives poorly or believe yourself to drive poorly the reluctance to be assessed when driving is high. Moreover, the variability within one driver could also be a sign that being part of one estimator group can vary depending on the driving task for example. Belonging to a group of estimator might not be stable over time. Further research need to investigate this question on how stable is driver regarding self-assessment of his or her own ability to drive.
In addition to the difference in numbers for the estimator categories using the three different methods no clear trend was seen looking at the individual drivers and how they were categorized using the three methods. This clearly shows the difficulty in categorizing drivers pointing that further research is required to find the most suitable and efficient method to do so. However, it can be argued that since the different driver categories exist this knowledge could be used as a first step developing driver assist technologies as a clear difference in attitude towards “me as a car driver” was noticed in the interviews seeing a higher degree of humble acceptance to information and positive criticism from those believed to be adequate estimators compared to those being over estimating the ability.

All drivers had a visual acuity level required for holding a driving licence in Sweden. Moreover, results from the UFOV tests and from the TMT A&B showed a good processing speed and a shared attention. The participants’ results were in line with reference data to a match population (Edwards 2006). A correlation between the UFOV test in relation to number of errors in the B On-road test was found with drivers having better performance in the test having fewer errors in the on-road driving assessment. This correlation was also found with the gain of FR-TMT. Even though a correlation between the cognitive test and the number of errors in the on-road driving could be found in the study, it is not possible to use this test as a reliable method to assess the ability to drive in order to identify a specific driver estimator category. This may be due to the limited number of participants or the fact that both the on road driving assessment and self-assessment through a following interview are so directly coupled. It could also be the case that the belonging to an estimator group might not be stable over time and could vary depending on the task characteristic for example.

The FR TMT is a developed form of the original TMT (Tombaugh, 2004). The fixed conditions should be quite close to the traditional TMT. Thus, AF should measure visual search speed (and some motor speed but less than in the original drawing task of TMT). While, BF requires switching and maintaining two tasks, thought traditionally to measure executive processes (and mental flexibility), and therefore it should predict essential problems in correctly timed switching from road to other tasks and back. It was also found that traditional TMT and FR TMT (A and B) correlated very well. For the executive part, BF minus AF (or BF/AF) is preferable, as an indicator of visual search performance. The problem with B is that it depends somewhat on education, more specifically, on how well participants know the alphabet order. Thus, it is of value to note educational level when building a reference database. The educational level was recorded for the subjects in the study and thus, the collected data can be used in the future as input to a reference database. Considering how well and fast drivers update the road view and other tasks, the visuospatial memory component should predict fluent and reliable time-sharing as well. Thus, the gain variable, computed (as (AR-AF)/AR), could be an indicator of how much participants benefit from stable targets in relation to random (moving) targets. It was found that the gain factor correlates positively with the B On-road scores in a similar fashion as the UFOV3 does. This could be argument for further investigations of the gain factor as an indicator of potential risk.

Besides the recommendation for specifically elderly female drivers to keep up practice and try to drive on a regular basis, it is again clear that intersections and the ability to keep attention to other road users in these situations needs focus both from a car design perspective, driver assist, but also from the point of possible training for older drivers. Even though the maneuvering errors showed a difference between the drivers of the automatic versus the manual driven car but no significant correlation to errors in general was found in this study, it seems still logical that any measures to make the driving task simpler for the older driver should be encouraged. This specifically relates to driving in complex scenarios like intersections or areas where other road users appear frequently. The other area for focus is speed adaptation, how this can be supported and/or trained again with the ambition to help older drivers to keep attention to other road users around them.
5. Conclusions

Regarding the SAFE MOVE project, following conclusions can be drawn:

- Identifying the traffic scenarios and behaviour that are especially difficult for older drivers: speed adaptation and lack of attention. Speed adaptation problems, driving too fast for the situation, were found in areas with many pedestrians and situations where the possible visual attention to other road users was limited. Attentional errors to typically speed limit signs and to other road users occurred to a larger extent in roundabout and intersection scenarios specifically with right of way.

- Examine the relationship between cognitive and driving ability: Participants having the higher number of errors during the on-road driving are the ones who are slower in general, a slower processing speed for a divided attention task and for a selective attention task found in the results of the UFOV test and FR-TMT.

- Investigate the relation between the driving behaviour and whether the driver is over, under or adequate estimators: Although there is some methodological difficulty to identify whether a person is adequate, over or under estimators, we found that the majority of the drivers are adequate estimators, the second biggest group is over estimators and the third one the under estimators. Results from the interview showed a relation where the adequate estimators showed higher acceptance to driving too fast for the situation whilst the over estimators did not see this problem with themselves but more with other drivers.

- Recommendations regarding scenarios to take into account in order to take preventive actions, such as retraining sessions or developing driver assistance systems. The two behaviours, speed adaptation and visual attention at roundabout and crossing will be introduced for the training in the simulator and for the demonstration of assistance systems both in-vehicle and in the simulator.
References


The Swedish National Road and Transport Research Institute (VTI), is an independent and internationally prominent research institute in the transport sector. Our principal task is to conduct research and development related to infrastructure, traffic and transport. We are dedicated to the continuous development of knowledge pertaining to the transport sector, and in this way contribute actively to the attainment of the goals of Swedish transport policy.

Our operations cover all modes of transport, and the subjects of pavement technology, infrastructure maintenance, vehicle technology, traffic safety, traffic analysis, users of the transport system, the environment, the planning and decision making processes, transport economics and transport systems. Knowledge that the institute develops provides a basis for decisions made by stakeholders in the transport sector. In many cases our findings lead to direct applications in both national and international transport policies.

VTI conducts commissioned research in an interdisciplinary organisation. Employees also conduct investigations, provide counseling and perform various services in measurement and testing. The institute has a wide range of advanced research equipment and world-class driving simulators. There are also laboratories for road material testing and crash safety testing.

In Sweden VTI cooperates with universities engaged in related research and education. We also participate continuously in international research projects, networks and alliances.

The Institute is an assignment-based authority under the Ministry of Enterprise, Energy and Communications. The institute holds the quality management systems certificate ISO 9001 and the environmental management systems certificate ISO 14001. Certain test methods used in our labs for crash safety testing and road materials testing are also certified by Swedac.

We have about 200 employees and are located in Linköping (head office), Stockholm, Gothenburg, Borlänge and Lund.