Silver People.
Assisting older drivers with entering the motorway

Chris Dijksterhuis[1], Janet Veldstra[1], Dick de Waard[1], & Sjef Moerdijk[2]
[1] University of Groningen, Traffic and Environmental psychology group
[2] Rijkswaterstaat, Ministry of Infrastructure and the Environment
The Netherlands

Abstract

We are living in an ageing population. In the Netherlands for example, the share of people aged 65 and above will increase to about 20% in 2020. It is likely that the proportion of car drivers in this age category will increase in a similar way or even more. The Dutch government aims to facilitate this development by specifically looking at ways to support the older driver. There are indications that older drivers are more likely to get involved in an accident when entering the highway. In addition, older drivers tend to drive slowly on the acceleration lane. In other situations, e.g. when turning left, this is a good strategy because it increases available manoeuvring time, but in case of merging it is deemed wiser to match speed to the speed on the main lane. Therefore, we designed and selected variable message signs aimed at assisting speed choice. First, we invited a small group of older drivers for a focus session, thereby greatly reducing the number of designs to test. Second, the selected signs were implemented in a driving simulator and shown dynamically to older drivers and to drivers in a younger control group. Results indicate one clear winning design.

Introduction

According to demographic prognoses of Statistics Netherlands, the share of people aged 65 or older in the Netherlands will steadily rise from 15.6% in 2011 to a peak percentage of 25.9% in 2039 after which it will take 21 years for this share to come down one percentage point again. This amounts to an absolute increase in this age category of about 2 million people or a 78% increase (CBS, 2012a,b). The Dutch projection trend is similar but somewhat deviating from European projection averages as it is expected that in the EU, the share of the population aged 65+ will keep rising to 29.3% at the end of the projection period in 2060. This is consistent with the observation that the grey wave is moving in south-east direction within Europe, implying for example that by 2040, Romania and Latvia will have the oldest populations while Nordic and Western European countries will have the youngest populations (Eurostat, 2011).

One factor contributing to the increasing share of older ages in society is that people live longer. The life expectancy of the Dutch population for example, has been rising

In D. de Waard, K. Brookhuis, F. Dehais, C. Weikert, S. Röttger, D. Manzey, S. Biede, F. Reuzeau, and P. Terrier (Eds.) (2012). Human Factors: a view from an integrative perspective. Proceedings HFES Europe Chapter Conference Toulouse. ISBN 978-0-945289-44-9. Available from http://hfes-europe.org

for several decades, partly due to the declining effects of so called lifestyle diseases such as cardiovascular diseases, smoking and also traffic accidents. The life expectancy will likely continue to rise throughout the first half of this century from 71.4 years on average in the 50ies to 85.9 years over a century later (CBS, 2012c,d).

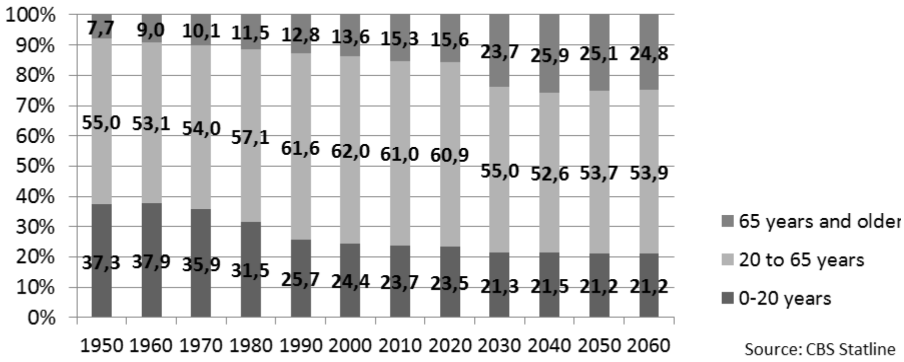

Figure 1 (Projected) Dutch population composition

These trends will likely lead to an increase in the share of older drivers as well. Moreover, due to several other projected developments, such as a longer healthy and socially active life, an increasing retirement age, and an increasing percentage of older drivers in possession of both a driver's licence and a car, the proportion of miles driven by the older age group is expected to increase even more than the general demographic increase. In other words, an increasing and substantial amount of older people will drive a lot on average (Jorritsma, 2006).

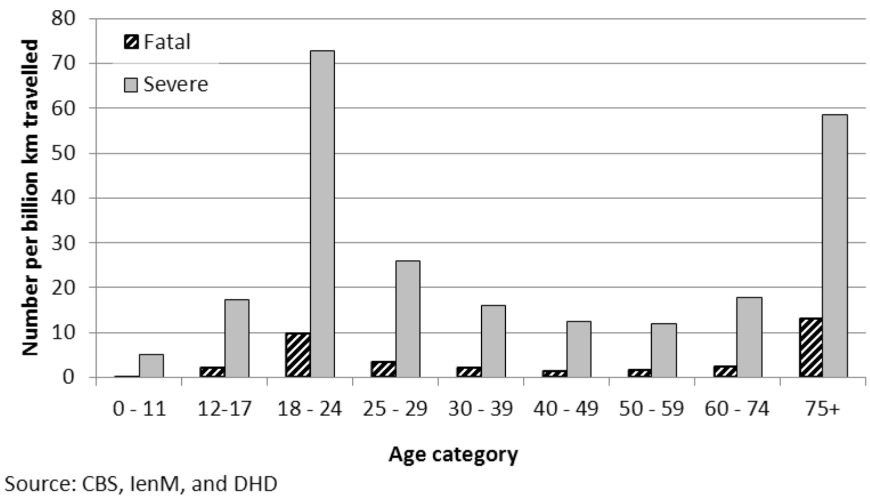

Figure 2. Mean yearly accident rate, resulting in death or severe injury, involving a passenger car between 2005 en 2009 in the Netherlands.

Although the absolute number of severe accidents in the older age categories is similar or even somewhat smaller than for the ages between 30 and 60 years, when compensated for exposure, an entirely different pattern emerges, as can be seen in Figure 2 (SWOV, 2012). Older traffic participants, especially older than 75 years of age, have a relative high risk of dying or suffering a severe injury as a result of accident involvement.

Causes for this high risk are the result of either an increased physical frailty or an increased crash involvement risk (Koppel et al., 2011; Li et al., 2003). However, an important confounding factor for crash involvement risk is low annual mileage (SafetyNet, 2009). Research has shown that the association between age and crash rates disappears when matched for annual mileage (Hakamies-Blomqvist et al., 2002; Janke, 1991; Langford et al., 2006). Given the projected societal trends described above, the high crash involvement risk can be expected to go down for the future generation of older drivers.

Accident statistics aside, ageing is accompanied by functional limitations that are important for safe driving. These may be related to the sensory organs, for example a reduced ability to resolve details on moving objects (dynamic visual acuity), more sensitivity to glare, impaired night time acuity and a narrowed visual field (e.g. Klein, 1991). Older drivers may also suffer a decline of cognitive functions, such as the ability to select relevant information (e.g., Davidse, 2007). In addition, physical limitations such as reduced joint flexibility may lead to reduced neck rotation and the ability to check the blind spot when changing lanes, which is important when entering the motorway for example (Davidse, 2007).These limitations may well contribute to an overrepresentation of older drivers in specific types of accidents. For example, accidents caused by colliding with fixed objects or not yielding when turning left at an intersection (e.g., Koppel et al., 2011). However, as is apparent from mileage corrected crash involvement risk, these limitations do not automatically lead to unsafe driving in general. Older drivers often compensate for their limitations, for example by avoiding driving in the dark or during peak traffic hours, by obeying traffic rules and not engage in distracting activities while driving, or reducing speed and keep more time headway when approaching a potentially complex road situation, such as intersections (AAA, 2006).

Even though the motorway system is a relatively safe part of the road network because of the wide carriageways and separation of oncoming traffic, there are indications that older drivers are more likely to be involved in an accident for which the pre-crash manoeuvre is merging, changing lanes, overtaking, or passing near interchanges (e.g. HSIS, 1996). With respect to entering the motorway, several studies have shown potential problematic behavioural differences between younger and older drivers. For example, De Waard et al. (2009) and Malfetti and Winter (1987) found that older drivers tend to keep a slower speed on the acceleration lane: possibly compensating for a decreased ability to judge distances and to provide themselves with more time to find an acceptable gap between the traffic stream on the main road. In other situations, this is usually a good strategy because it increases available manoeuvring time, but in case of merging it is deemed wiser to match speed to the speed on the main lane as a smaller gap can then be accepted.

Therefore, interventions aimed at either guiding the mainstream traffic in keeping sufficient time headway or at helping drivers to match their speed to the driving speed on the main road are hypothesised to decrease accidents related to the merging manoeuvre, especially for the older drivers.

An example of an already investigated merging assist (from the centre lane to the right-hand lane) was part of the so-called ‘thinking road surface’ in which drivers on the right-hand lane should drive next to a moving LED-light bar and thereby making space for traffic on the centre lane so they can merge (De Waard et al., 2004). Another example is placing chevron arrows on the right-hand lane to help drivers with keeping enough time headway. The latter intervention led to an encouraging reduction in accidents at the test site (56%; Helliar-Symons et al., 1995). Other proposed interventions include placing LED-light bars to guide traffic on the acceleration lane in addition to guiding traffic on the main road, painting the road surface to naturally stimulate traffic to speed up on the merging lane, and providing personalised information to the merging traffic by using variable message signs (VMS; Ying, 2010).

Deploying VMSs is a cheap intervention compared to infrastructural interventions such as constructing longer and wider merging lanes, and the maintenance costs of the LED-light bars, therefore rendering VMSs a more realistic scenario. However, before exposing drivers to a VMS and test its effects on driving behaviour, a feasible design is necessary. The focus of the current study was to design a VMS that will assist traffic on the acceleration lane with choosing an appropriate speed and thereby match their speed to the speed on the right hand motorway lane.

Several theories and guidelines are available to persuade drivers to change behaviour by providing information. For example, McGuire (1986) listed six information-processing steps that need to be completed before a behavioural change will occur. These steps are 1) Presentation of the information, 2) Attention to the information, 3) Comprehension of the arguments and position the information advocates, 4) Yielding to the message contents and its conclusions, 5) Retention of the changed attitude, and 6) Behaviour based on the changed attitude. Please note that these steps work in hierarchy. Even a successful completion of steps 1 to 5 does not guarantee a behavioural change. From attitude literature it is known that the overall correlation between attitudes towards behaviours such as speeding and the actual shown behaviour is not always high (e.g. Rothengatter, 2002); however, they can be seen as a perquisite in the current situation.

The required information-processing steps are mediated by both cognitive-ergonomic and social-psychological principles (Dicke-Ogenia & Brookhuis, 2008). Social-psychological principles include habitual driving and attitudes. However, when designing content for the VMS, we have emphasised on the cognitive-ergonomic principles by De Vries-De Mol & Walraven, 1988. These principles mainly affect the first four steps of the McGuire list. These cognitive ergonomic guidelines include: conspicuity, legibility, comprehensibility, and credibility.

Conspicuity indicates the extent to which information draws attention and is influenced by position, moment and medium. *Legibility* indicates how well information can be read and is affected by factors such as font and the use of colours. For example, less colours are usually preferred by the road user and using more colours can lead to confusion (Lai, 2010; Roskam et al., 2002). Information density is another factor influencing legibility. Displaying more information on a VMS may result in linear or sometimes even exponential increase in reading time (Roskam et al., 2002). *Comprehensibility* refers to the ease with which the traveller can understand the information. Ambiguity, consistency, spatial and graphical grouping, and using relatively cultural independent symbols instead of text are factors influencing comprehensibility (Roskam et al., 2002). When travellers believe that the information is true and applies to them, the information is *credible.* Without credibility information is likely to be ignored in the future, even if it is relevant at that point in time (Dicke-Ogenia & Brookhuis, 2008).

Given the focus of the current study on developing, assessing and selecting various potential VMS designs, we chose to emphasise step 2 to 4 in McGuire's list: attention, comprehension, and yielding, and assessed designs with respect to their legibility, comprehensibility, and credibility. This leads to the following research question:

What is readable, understandable and meaningful information on dynamic information panels to support the speed choice just before merging for older road users? To answer this question we designed a two stage study. First, a small number of feasible designs were preselected based on results from a focus group session. The selected signs were then demonstrated using driving simulator software, to both younger and older drivers.

Stage 1: the focus group session

Method

Given the time required to assess the large amount of possible designs in an experimental design, a small number of feasible designs was preselected based on both quantitative and qualitative data acquired from a small group of relative old drivers during a focus session. We have chosen not to provide a comprehensive report for this stage of the study to avoid a lengthy paper and because we consider the focus group session as a mean to preselect designs for Stage 2, which will be described in more detail.

Participants
Nine participants (six males) joined the focus group session, they varied in age between 55 and 66 years (M = 61.2, SD = 4.5). The participants drove a car for 5.7 hours per week on average (SD = 3.8). All of them drove on the motorway on a regular basis; two participants indicated about once per month, while the other seven participants indicated a weekly frequency. The participants received a small monetary reward to compensate for any travelling costs they might have had in getting to the study site. All participants signed an informed consent and the study was approved by the ethical commission of the psychology department of the University of Groningen.

Procedure

The focus session was held in a ‘classroom’. The participants were all facing the session leaders, but could interact with each other. After taking some time for introductions to make everybody feel comfortable, participants were asked to individually rate two statements on 26 designs on 5-point Likert scales. The designs were presented statically on a screen for 1.5 seconds each to mimic the limited time drivers have to look at traffic signs. Participants were allowed to ask questions, but interaction with each other was kept to a minimum. After this, the designs were discussed in the group. At the end of the discussion, participants were asked to write down what they considered to be the best and the worst design.

Signs

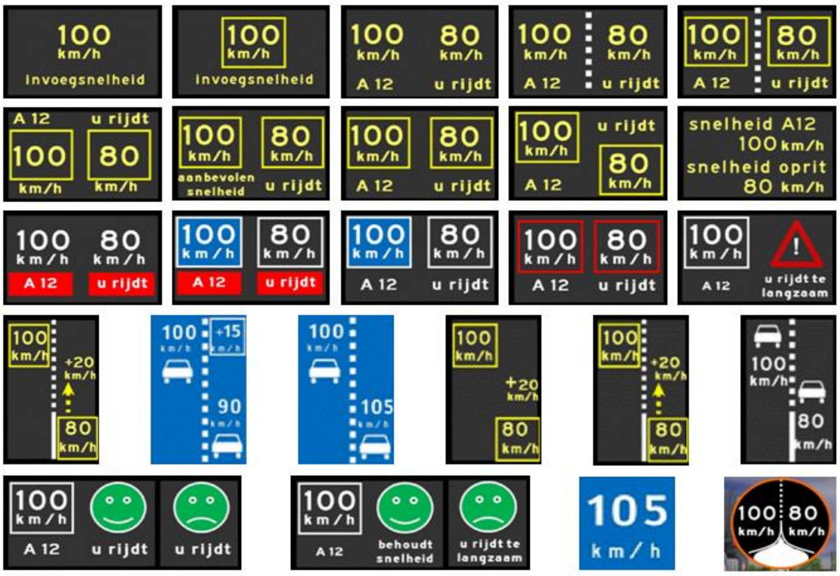

Figure 3. A composition of all signs presented to the focus group. Several factors were assessed such as the use of yellow vs. white text colour; displaying speed information in boxes vs. no boxes; current speed on the motorway only vs. speed motorway and current personal speed; using a broken line indicating the road lineage vs. no broken line; providing information only vs. suggesting acceleration or deceleration; using the blue signs to trigger associations with traditional advisory speed signs as used in the Netherlands. Translations of Dutch terms: “Invoegsnelheid” = merging speed; A12 = M12; “aanbevolen snelheid” = advised speed; “u rijdt” = you’re driving; “snelheid A12” = speed M12; “snelheid oprit” = speed acceleration lane; “u rijdt te langzaam” = you’re driving too slowly; “behoudt snelheid” = maintain speed.

The presented designs were organized into several themes: information content, colours, sign position with respect to the road, and the organisation of the information on the sign’s display. The statements that needed to be rated varied slightly per theme and to avoid confusion, all signs within a theme were presented as a block of subsequent signs. All ratings asked were related to legibility, comprehensibility, and credibility of the signs. Furthermore, one design could be part of more themes, and could therefore be rated at two different times using different Likert statements. Figure 3 shows a composition of all the signs that were presented to the focus group.

Results/Conclusions

The selected VMSs are depicted in Figure 4. The results from the Likert scales revealed a high prevalence of positive ratings on legibility and comprehensibility for sign A, while sign G received the lowest ratings for legibility and comprehensibility. Sign G was also indicated as 'worst' design most frequently at the end of all discussions, while most participants selected Sign B as 'best' design.

Using a warning sign symbol in this situation (signs D and E), especially for the instruction to accelerate, was a topic of debate. The focus group participants feared 'startle' or panic reactions. However, ratings scores for these signs were very good and therefore selected for further research.

To complement the 'you drive too slowly' and 'you drive too fast' warning signs, sign C indicates that the current speed is adequate. Using the smiley symbol to strengthen this message was discussed but dismissed. Even though real-life examples of VMSs using this symbol can be found in the Netherlands, most participants agreed that using a smiley is inappropriate for older drivers since they might not be very familiar with this symbol. Despite slightly lower rating scores, sign F was also selected for further research because it was well received during the discussion. Signs G and H were included mainly for reasons of comparison (control). With regard to sign location, directly above and on the right hand side of the acceleration lane were rated best. We decided to use the latter location for Stage 2 for practical reasons, as roadside VMSs may be easier to place in a real life situation.

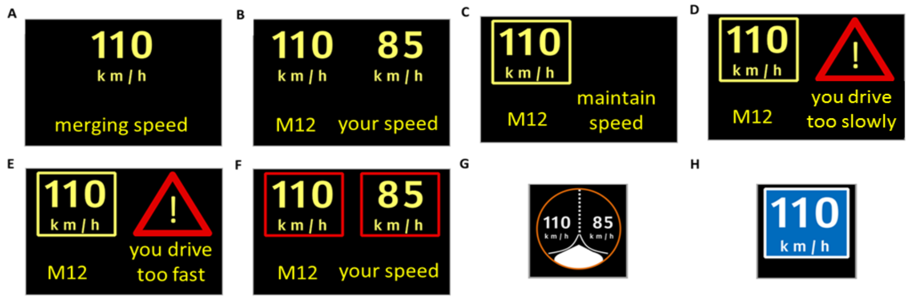

Figure 4. Selected signs as demonstrated in Stage 2 except that terms are translated from Dutch for the readers' convenience.

Stage 2: simulation-based evaluation

In this stage, the selected VMSs were demonstrated to older drivers and to a control group of younger drivers on a laptop, on which StSoftware© driving simulator software ran.

Method

Participants

The characteristics of both the control group and the group of older drivers are summarised in Table 1. As can be seen, the mean age of the older group is 65 years, while the control group is 30 years of age on average. Although potential candidates were asked if they use the motorways before inviting them to watch the simulation on the laptop, one of the older participants had not driven a car that year. We still used her rating scores because she had driven extensively before that year and had stopped driving recently for medical reasons.

Table 1. Participant statistics

Group	Older (n = 24, 14 male)				Control (n = 25, 13 male)			
	M	SD	Min.	Max.	M	SD	Min.	Max.
Age (years)	65.4	7.5	51	83	29.8	3.5	25	36
Holding license (years)	42.1	7.2	25	59	7.3	3.8	2	15
Mileage (km/year)	8400	13100	0	40000	6500	6700	500	20000
Driving time (hours/week)	5.5	6.9	0	30.0	2.4	2.6	0.25	10.0

In addition, the participants were asked how often they drove on the motorway. In contrast to what can be expected, the (young) control group had a lower annual mileage and drove on the motorway less frequently compared to the older group. This may be explained by the fact that almost all participants in the younger group live and work in the city of Groningen and use their bicycle or public transportation to go to work for example. All participants signed an informed consent and the study was approved by the ethical committee of the psychology department of the University of Groningen.

Table 2. Frequency of driving on the motorway

Group/Frequency	Older	Control
Never	1	0
< Once per year	1	0
Once per year	0	1
Once per month	3	12
Once per week	8	6
> Once per week	11	6

Procedure

Participants viewed the simulations from the driver’s perspective of the car driving automatically from the beginning of an acceleration lane to just after a VMS that was located about 300m before the merging lane and at the right hand side of the acceleration lane; at this point the simulator was stopped. Before the actual demonstrations began, participants were shown an example demonstration with an empty VMS in it. After this, all eight signs were shown according to a randomised schedule, creating a mixed experimental design of one between subject factor and one within subject factor: group (2) x sign (8) and participants were asked to rate the demonstrated VMSs. Most older drivers were asked to participate while visiting a shopping mall, while the younger control group watched the demonstration at their homes. After watching all rides, the participants were presented with an overview of all signs and were requested to point out the best and the worst design.

Rating scales
Participants were requested to rate to what extent they agreed with statements related to legibility, comprehensibility, and credibility on 5-point Likert scales for each sign. An example statement is: 'The information on the sign is comprehensible'. The participants could rate this statement by marking: strongly agree, agree, neutral, disagree, or strongly disagree. When 'disagree' or 'strongly disagree' was marked, the participants were invited to write down in keywords what sparked their answer. The Dutch terms we used to assess legibility, comprehensibility, and credibility were respectively: 'leesbaar', 'begrijpelijk', and 'zinvol'. The meaning of these translations might deviate slightly from the original English meaning. Especially 'zinvol' might also be translated as 'useful' or 'meaningful'.

Statistical analyses
All data was statistically analysed using. PASW Statistics 18, Release Version 18.0.0 (SPSS, Inc., 2009, Chicago, IL, www.spss.com). From visual inspections of rating scores, frequency tables and subsequent use of the Kolmogorov-Smirnov tests of normality, it was clear that the data in none of the cells of the group (2) x signs (8) design and for none of the three rating scales reflected the normal distribution required for GLM repeated measures testing. Therefore, we used the non-parametric Friedman's ANOVA for multiple dependent samples. This test was completed six times in total: for each rating (legibility, comprehensibility, and credibility) and within each group (older drivers and the younger control group). In addition, the non-parametric Mann-Whitney U test for two independent samples was used to test the differences between the two groups for every rating, resulting in 24 between group tests in total (8 signs x 3 dependent variables).

Results

The mean ratings per group are shown in Figure 5 and the statistical test results of the Friedman's ANOVA's are presented in Table 3. To start with, the Mann-Whitney U tests did not reveal difference between the older group and the younger group, with the exception of the lower comprehensibility ratings by the older group for sign G. However, given the danger of change capitalisation given the quantity of tests, we will not discuss this any further. As can be seen in Figure 5, all signs got positive ratings for all three dependent variables except for sign G. Moreover, there was an effect of the sign factor for all three variables (see Table 3). To further clarify differences between signs, all rating scores, averaged across the two groups, were ranked and as such presented in Table 4.

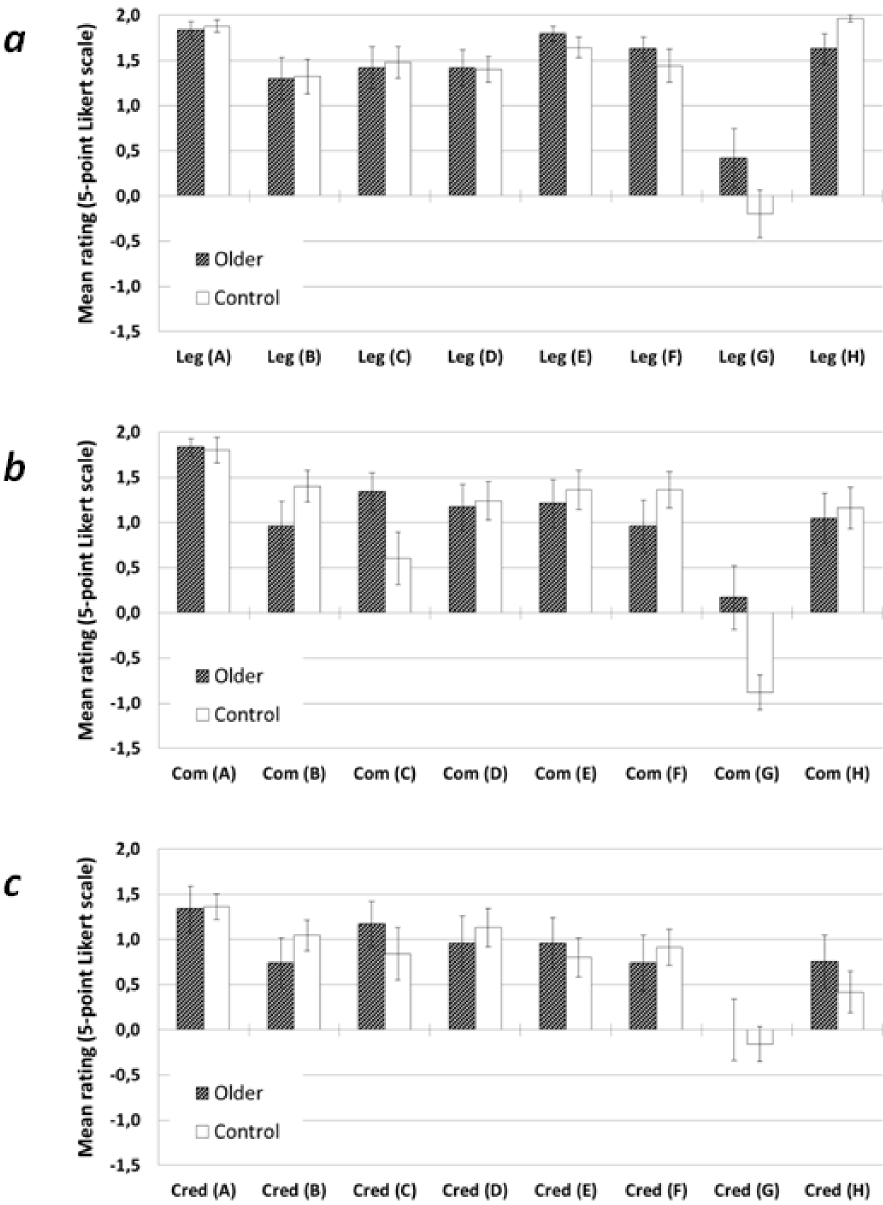

Figure 5. Mean ratings on 5-point Likert rating scales of both the older group and the younger control group for legibility (Leg: 5a) , comprehensibility (Com: 5b), and Credibility (Cred: 5c) for all signs. Sign codes A-H coincide with the signs as presented in Figure 4. Values: -2 = strongly disagree, -1 = disagree, 0 = neutral, 1 = agree, and 2 = strongly agree. Error bars represent the standard error.

Table 3. Results of six Friedman's ANOVA's (within subject factor is Sign type)

		Legibility	Comprehensibility	Credibility
Older	F	80.9	70.3	32.5
	p	<0.001	<0.001	<0.001
Control	F	34.0	19.3	16.8
	p	<0.001	0.01	0.02

Table 4. Ranked mean rating scores for all signs.

	Legibility		Comprehensibility		Credibility	
rank	Sign	Score	Sign	Score	Sign	Score
1	A	1.9	A	1.8	A	1.3
2	H	1.8	E	1.3	D	1.0
3	E	1.7	D	1.2	C	1.0
4	F	1.5	B	1.2	E	0.9
5	C	1.5	F	1.2	F	0.9
6	D	1.4	H	1.1	B	0.9
7	B	1.3	C	1.0	H	0.6
8	G	0.1	G	-0.4	G	0.0

Sign A (a simple 'merging speed' text; see Figure 4) was rated best on all three variables, while sign G was rate worst. Sign H (the blue speed advice sign) did very well on legibility, but it was ranked in the bottom half with respect to comprehensibility and credibility. Sign E (you drive too fast) was rated second best on comprehensibility, did well on legibility, but was only ranked fourth on credibility. In contrast, the instruction: 'you drive to slowly' was ranked second on the credibility scales and did well on the other scales as well.

When asked to point out the best sign, sign A was selected most frequently by both the older and control group (8 and 13 times respectively). In addition, signs H and E were each selected five times and sign F four times as best by the older participants. The younger participants picked signs B and F four times as best sign. Sign G was pointed out most often by both groups as the worst sign. Sign G got 11 votes from the older group, while sign F was pointed out five times. The control group selected sign G almost unanimously (24 times).

Discussion

To recapitulate, several potential VMSs were assessed with regard to their legibility, comprehensibility and credibility by a group of older drivers and a control group of younger drivers. Two very clear results came out of this study. First, Sign A was evaluated as best sign, both during the focus group session and after demonstrating it using simulator software. Also both the older group and the younger control group rated this sign overall as best. This confirms a well-known principle in cognitive ergonomics that less is usually better. However, one participant commented that the message displayed on sign A is still ambiguous as it is not entirely clear whether the driver's current speed is indicated or the advised merging speed. This may indicate that small changes may still improve the design.

The second clear finding is that Sign G, representing a direct link to previous research by Ying (2010), was assessed to be the worst sign. All other signs were also positively assessed; albeit results were less clear compared to Sign A.

Limitations

The most obvious limitation of the current research is that no behavioural data were collected that are necessary to confirm the potential a particular sign may have in changing behaviour. The focus of this study was on assessing comprehension of potential variable message signs while, as stated in the introduction, good assessment does not guarantee behavioural change by the same drivers. A simulator and preferably a field study are necessary to draw final conclusions.

The groups' driving behaviours as reported by the participants deviated slightly from what can be expected from general driving statistics. In general, younger drivers, spend more time behind the steering wheel and drive on the motorway more frequently than older drivers. As mentioned in the method section, the probable reason for this fact is that participants in the younger group did not need a car to get to work in this particular context.

The older group was 65 on average may be considered relative young when taking into account that increases in accident risk start more clearly after 65 years and increase to a large extent after the age of 75. In addition, the mileage reported by the participants of the older group does not show the low numbers which were shown to be such an important confounding factor in the age-risk association (e.g. Langford et al., 2006). In essence, one may argue that the older group did not report to behave in a way that may be expected from older drivers that are most at risk. To what extend this may have impacted results is difficult to say. For follow-up studies it is advised to recruit older drivers.

As one participant pointed out: the VMS might instruct a driver to increase speed while this is not possible if the driver in front of you ignores it, possibly triggering irritation. Ideally, any speed assistant should take the speed of the vehicle ahead into account. Currently, in-vehicle driver assistance systems are being developed that have this functionality (Schwarze, 2012).

Conclusions

The VMS with the lowest information density, that only indicated an advised merging speed, was rated as the best sign, as revealed by both qualitative and quantitative data analysis. Suggestions for future research would be to repeat the study using a more representative sample of older drivers and to confirm the potential of the signs for behavioural change in a simulator or field study.

References

AAA (American Automobile Association) Foundation for Traffic Safety (2006). The Older and Wiser Drivers. Washington, DC, U.S.A.

CBS (Centraal Bureau voor de Statistiek), Statline (2012a). Bevolking; kerncijfers, Available at http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=37296NED&D1=14-18&D2=0,10,20,30,40,50,60&VW=T, Accessed: September 6, 2012.

CBS (Centraal Bureau voor de Statistiek), Statline (2012b). Kerncijfers van diverse bevolkingsprognoses en waarneming, Available at http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=70737NED&D1=5-7&D2=l&D3=70,90,100,l&HDR=T&STB=G1,G2&VW=T, Accessed: September 6, 2012.

CBS (Centraal Bureau voor de Statistiek), Statline (2012c). Levensverwachting; geslacht en leeftijd, vanaf 1950 (per jaar), leeftijd op 31 december: 0. Available at: http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=37360NED&D1=3&D2=a&D3=0&D4=0,10,20,30,40,60&HDR=G1,T&STB=G2,G3&VW=T, Accessed: September 6, 2012.

CBS (Centraal Bureau voor de Statistiek), Statline (2012d). Kerncijfers van diverse bevolkingsprognoses en waarneming. Available at: http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=70737NED&D1=14-15&D2=l&D3=60,70,80,90,100,l&VW=T, Accessed: September 6, 2012.

Davidse, R. (2007). *Assisting the older driver: Intersection design and in-car devices to improve the safety of the older driver*. SWOV-Dissertatiereeks, Leidschendam, Netherlands.

De Waard, D., Dijksterhuis C. and Brookhuis K. A. (2009). Merging into heavy motorway traffic by young and elderly drivers. *Accident Analysis & Prevention*, *41*, 588-597.

De Waard, D., Brookhuis, K. A., Noordmans, M. C., Hogema, J. H. and Visscher, R. M. (2004). A "Thinking Road Surface". In De Waard, K.A. Brookhuis, and C.M. Weikert, *Human Factors in Design* (pp. 83-94), Maastricht, the Netherlands: Shaker Publishing.

Dicke-Ogenia, M., & Brookhuis, K.A. (2008). Improved access to cities through travel information on full colour information panel. In: European Transportation Conference 2008, Leeuwenhorst Conference Center, The Netherlands

Lanzieri, G. (2011). The greying of the baby boomers. Eurostat, Statistics in focus, 23. Retrieved from http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/publication?p_product_code=KS-SF-11-023

Hakamies-Blomqvist, L., Raitanen, T. & O'Neill, D. (2002). Driver ageing does not cause higher accident rates per km. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*, 271-274

Helliar-Symons, R., Webster, P. and Skinner, A. (1995). The M1 Chevron Trial. *Traffic Engineering and Control*, *36*, 563-567.

Highway Safety Information System (HSIS) (1996). Analysis of Older Drivers on Freeways. Federal Highway Administration, Washington, DC, U.S.A.

Janke, M.K. (1991) Accidents, mileage and the exaggeration of risk. *Accident Analysis and Prevention*, *23*, 183-188.

Jorritsma, P. and Kalter, M.O. (2008). Grijs op reis: Over de mobiliteit van ouderen. Kennisinstituut voor Mobiliteitsbeleid (KiM), Netherlands.

Klein, R. (1991). Age-Related Eye Disease, Visual Impairment, and Driving in the Elderly. *Human Factors,33*, 521-525

Koppel, S., Bohensky, M., Langford, J., Taranto, D. (2011). *Older drivers, crashes and injuries. Traffic Injury Prevention, 12* , 459-467.

Lai, C-J. (2010). Effects of color scheme and message lines of variable message signs on driver performance. *Accident Analysis and Prevention, 42,* 1003–1008.

Langford, J., Methorst, R. & Hakamies-Blomqvist, L. (2006) Older drivers do not have a high crash risk – A replication of low mileage bias. *Accident Analysis and Prevention*, *28*, 574-578.

Li, G., Braver, E., & Chen, L. (2003). Fragility versus excessive crash involvement as determinants of high death rates per vehicle-mile of travel among older drivers. *Accident Analysis and Prevention, 35*, 227–235.

Malfetti, J.L. & Winter, D.J. (1987). Safe and Unsafe Performance of Older Drivers: A Descriptive Study. American Automobile Association Foundation for Traffic Safety, Falls Church, VA., U.S.A.

McGuire W.J. (1968). Personality and susceptibility to social influence. In E.F. Borgatta, W.W. Lambert (Eds.) *Handbook of Personality Theory and Research* (pp. 1130–1187). Chicago: Rand-McNally.

McGwin Jr., G., & Brown, D. B. (1999). Characteristics of traffic crashes among young, middle-aged, and older drivers. *Accident Analysis and Prevention, 31*, 181-198.

Roskam, A-J., Uneken, E., De Waard, D., Breker, S., Rothermel, S., (2002). Evaluation of the comprehensibility of various designs of a Full Colour Information Panel. In D. de Waard, K.A. Brookhuis, J. Moraal, and A. Toffetti (2002), *Human Factors in Transportation, Communication, Health, and the Workplace* (pp. 231-244). Maastricht, the Netherlands: Shaker.

Rothengatter, T. (2002). Drivers' illusions – no more risk. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*, 249-258.

SafetyNet (2009). Older Drivers, retrieved at 6 september 2012 from http://ec.europa.eu/transport/road_safety/specialist/knowledge/pdf/olderdrivers.pdf

SWOV (Stichting Wetenschappelijk Onderzoek Verkeersveiligheid), 2012. Doden en ernstig verkeersgewonden per afgelegde afstand (mld reizigerskilometers). Available at:

http://www.swov.nl/ibmcognos/cgi-bin/cognos.cgi?b_action=powerPlayService&m_encoding=UTF-8&BZ=1AAAB7pUZHH542oVOXW~CIBT9M1C3F3Oh1o_HPtBSo8ummzXZM7PXhrUFQxuX7NePWhNjlmU3cM7J4cAhyLfjfL~dZWsZt511uJYPlHM9S6eMQyKFWLIJiGweZnKazMVSzESSJNJnHoP_biZ26epV7Fcx5cuDNR2azqujrQt0NEroBIxqkIZytEFv1coU7YhG8o~QTrf6YK_BkzpUqsT7xDu6Cmv9WSHloJTpVO1FYQs0ngdwpu106dW5D6NrS~yyZkicfCWHpi48OtTfuvTnla5tg51XfXUg83ScbjebLN2vPYmXLL6rtc1ZmfL~x4LkLT4CEAYAjAEhBMg0isLoikB67xm7FuvLpyksnpRyngjlc8pDoBwZ5R_ULwaD3Qzya9hl9WIovezb~ACpc4us, Accessed: September 6, 2012.

Schwarze, A. (2012, August). Acceptance of new driver assistance system for merging into motorway traffic. Oral presentation at the 5th International Conference on Traffic and Transport Psychology. Groningen, The Netherlands.

Ying, H. (2010). *Silver Road Design. Elderly Friendly Highway Design*. (Unpublished master's thesis). Delft University of Technology, The Netherlands.