Miscalibration and Driver's Adaptation to Traffic Complexity. The Role of Gender, Age and Driving Experience

Corneliu E. Havârneanu[1], Simona A. Popușoi[1]

Initial receipt: 02.08.2015 Final revision received: 30.11.2015 Accepted: 03.12.2015

Abstract: For safe driving, an individual's skills have to match or to exceed the task demands of a traffic situation. In order to decrease task demands to fit their level of automated driving, three factors have to be taken into consideration, namely the assessment of personal driving skills, the complexity of the driving task and the adaptation to task demands. The aim of this present study is to examine if drivers adapt their behavior depending on the complexity of the situation. Two hundred and fifty-five drivers (N_{men} = 126) participated in this study. In order to evaluate a driver's behavioral adaptation and miscalibration, two instruments were constructed specific to Romanian traffic situations and laws. Results showed an association between miscalibration and behavioral adaptation, even when controlling for gender, age and driving experience. Moreover, gender differences in both miscalibration and behavioral adaptation were found.

Keywords: miscalibration, behavioral adaptation, overconfidence.

1. Introduction

Road accidents are the leading cause of death and injury among those aged under 25 (WHO, 2013). More importantly, while young drivers may have skill deficits compared to older drivers, accidents involving young drivers are frequently associated with voluntary risk-taking. One study found that 50% of accidents involving young drivers could be cumulatively accounted for because of deliberate risk-taking behaviors, such as speeding, drunk driving and reckless or neglectful driving (Clarke, Forsyth & Wright, 2005; WHO, 2013). Going over the speed limit is considered to be an important factor of road accidents, explaining about 10% of road accidents and over 30% of deadly road accidents. In Romania, more than 20% accidents were caused by excessive speeding. For safe driving, driver's skills have to match or to exceed the task demands of a traffic situation (Fuller, 2005).

Two main categories of factors have been identified to explain the high risk of accident when it comes to novice drivers, namely factors related to task performance processes and those related to motivational factors. From the factors related to task performance, the high level of risk of young drivers is frequently related to the limited automation of driving routines (Fuller, 2005).

[1] Al. I. Cuza University, Iași, Romania, Faculty of Psychology and Educational Sciences

* E-mail of corresponding author: simona.popusoi@yahoo.com

The task of driving is considered to be self-paced (Fuller, 2005), thus the task demands can be modified by the driver. This being said, drivers can decrease task demands to fit their level of automated driving. For this process to be successful, three factors have to be acknowledged: (1) the assessment of personal driving skills, (2) the complexity of the driving task and (3) the adaptation to task demands. Kuiken and Twisk (2001) propose that, in a psychological context, *calibration* refers to the degree to which the driver perceives task demands and his/her skills accurately (see Figure 1 for a schematic representation of the calibration process). The driver can influence task demands through behavioral choices. Ideally, the demands should match the driver's ability. This is a function of regulation within the continuous driving process. Self-assessment is supposed to play an important role in this regulation process (Spolander, 1983).When demands and abilities correspond, the driving behavior is considered as calibrated (Milech, Glencross, & Hartley, 1989). Miscalibration is defined as being the individual's tendencies to estimate their own knowledge as being more precise than in reality (Biais, Hilton, Mazurier & Pouget, 2005).

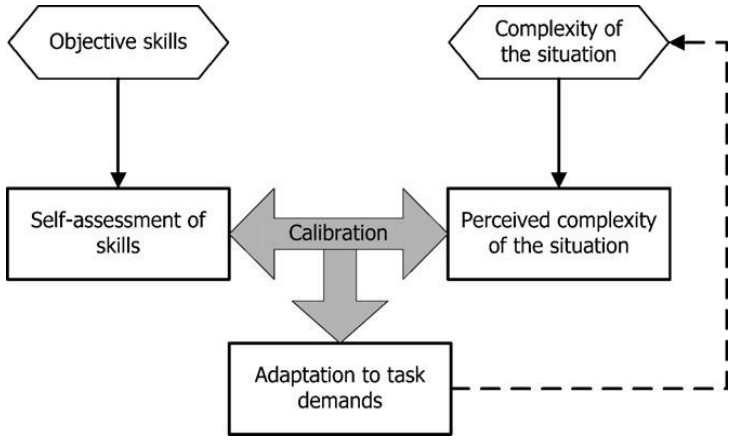

Figure 1. A working model of the calibration process (Kuiken & Twisk, 2001)

Self-assessment of skills

It is a general finding that drivers tend to assess themselves as being more skilled than the average driver. This is the case not only among young drivers but also among drivers in general in many countries, and it may indicate that drivers overestimate their driving skills (Hatakka, Keskinen, Gregersen, Glad, & Hernetkoski, 2002; Özkan, Lajunen, Chliaoutakis, Parker, & Summala, 2006; Sundström, 2008).

One of the key factors in calibration is the correct self-assessment of skills, which assumes overestimating or underestimating driving abilities. Previous studies have shown that young or novice drivers tend to overestimate their driving skills, thus increasing the risk of producing an accident (Gregersen, 1996). Overconfidence is also known as the optimism bias. Unrealistic optimism is defined as an individual´s tendency to believe that the probability to be involved in a negative event (e.g. such as producing an accident) is smaller than in reality. Researchers have investigated the overestimation of skills by asking drivers to compare their driving skills with other drivers. Results showed that novice drivers tend to overestimate their own abilities when compared with experienced drivers (de Craen, Twisk, Hagenzieker, Elffers, & Brookhuis, 2011). Also, men tend to overestimate their abilities more frequently compared to women (Nyberg & Gregersen, 2007), even if their driving performance is in line with their self-assessment of personal driving skills (Mynttinen et al., 2009). Previous studies on miscalibration showed either that novice drivers tend to overestimate their personal driving skills or not. Moreover, de Craen (2011) showed that experienced drivers are more confident about their own driving skills than novice drivers. Different results obtained over time can be explained by the way in which drivers were asked to evaluate their driving skills, in some studies being asked to compare with another regular driver, whereas in other studies they were asked to compare themselves with their peers.

Perceived complexity of the situation

Scholars make the difference between a hazardous perception and risk perception, by saying that a hazardous perception is the ability to detect potential dangerous situations whereas risk perception is considered to be a subjective evaluation of risk (de Craen, 2010). Sagberg and Bjornskau (2006) showed that there are significant differences between hazardous perception and risk perception by measuring the reaction time of the drivers on 31 traffic scenarios. The differences obtained showed that one´s reaction time decreases as a function of a driver's experience. Previous studies on the effect of the situation´s complexity on speeding behavior showed up when encountered with a complex situation; drivers reported a lower speed, especially experienced drivers who evaluated their own abilities in a correct manner (de Craen et al., 2011). Driving demands are determined in part by speed, road, environment and other driving properties. A driver's skills are determined by many factors including biological factors, knowledge, skills and allocation of resources. The "fit" between driver´s demands and capabilities contributes to the perceived difficulty of the tasks (de Craen et al., 2008).

Behavioral adaptation to task demands

A key factor in calibration is the ability to adapt as a function of the task complexity or demands. In order to be calibrated, there has to be a balance between a self-assessment of driving skills and the perceived complexity of the situation. Overestimating one´s abilities is considered to be a negative factor as it determines an inadequate adaptation to task demands (e.g. a driver who overestimates his/her driving skills are less likely to reduce their speed when it is raining). There is an association between risk perception and speed adaptation, indicating that drivers tend to travel over the speed limit when the situation is perceived as less risky (de Craen et al., 2008)

On this theoretical background, the first aim of this present study was to examine if drivers adapted their behavior depending on situational complexity. Due to the fact that previous findings suggested an association between demographics, miscalibration and behavioral adaptation (de Craen et al., 2008) the second objective of this study was to examine the relationship between gender, age, driving experience, miscalibration and the drivers' speed adaptation. Furthermore, we examined gender, age and driving experience as well as differences in both miscalibration and adaptation.

2.Method

2.1 Participants

Two hundred and fifty-five Romanian drivers participated in this study. The age of the sample (N_{men} = 126) ranged from 20 to 54 (*M* = 34.85; *SD* = 9.34). The driving experience ranged from 1 to 31 years (*M* = 10.98; *SD* = 7.03) and the average mileage was 213,513.33 km (*SD* = 242,849.31).

2.2 Measures

To study the extent to which complexity affects adaptation to task demands we used driving speed because reducing speed is the most straightforward way to decrease task demands. In order to do so, we constructed an Adaptation Test specific to Romanian traffic situations, using a previous test as a model (de Craen et. al., 2008). The adaptation test consisted of 25 traffic scenarios presented in two (almost) identical photographs, which differed in one single detail, thereby increasing the complexity of the situation (Figure 2). The participants had to estimate the speed they would use in all scenarios. A correct response was obtained if the driving speed estimated in the complex scenario was smaller compared to that estimated in the simple scenario. An incorrect response was considered when the participants either estimate a higher speed in the complex scenario or indicated the same speed in both scenarios. The difficulty index of the items was calculated as the proportion of the subjects that responded correctly. The two items were considered to be difficult (the difficulty index obtained was under .25, indicating that less than 25% of the participants responded correctly) whereas seven of them were considered to be

easy (the difficulty index obtained was over .76, indicating that more than 76% of the participants responded correctly). Most of the items (56%) had a medium difficulty index (ranging from .26 to .75). A total score was computed and the reliability of the test was satisfactory (Alpha .80).

Figure 2. Two examples of a complex (left) and simple (right) situation in the Adaptation Test.

In order to estimate the *miscalibration*, we constructed an instrument meant to evaluate the level of trust the drivers had in their knowledge when it came to Romanian traffic laws and legislation. Twenty-eight items were constructed with two answer options, one of which was correct. The difficulty index of the items was calculated as previously described. Three items were considered to be difficult (the difficulty index obtained was under .25, indicating that less than 25% of the participants responded correctly) whereas 10 of them were considered to be average (the difficulty index ranging from .25 to .75). Most of the items (53%) had a low difficulty index (the difficulty index obtained was over .76, indicating that more than 76% of the participants responded correctly). Eight of the items with low difficulty were excluded. After choosing their answer, the drivers had to estimate the level of certainty they had in their answer, from 50% (e.g. the answer made was random) to 100%. Due to the fact that the drivers may have chosen their answers randomly, miscalibration is evident when estimating a higher percentage (e.g. more than 50% were sure of their answer) for an incorrect answer. The total score for this instrument was calculated as the difference between average percentage for all the items and the average percentage for correct ones. *Overconfidence* was evident when a positive score was obtained (e.g. drivers considering to know more than in reality) and a negative describing *underconfident* drivers (e.g. drivers considering they know less than in reality). The 0 (zero) score is meant to describe *calibrated* drivers.

3. Results

Miscalibration and the adaptation test in relation with demographics

The Pearson correlation coefficient between miscalibration and adaptation indicate a small but negative and significant association (r = -.14; p = .02). Moreover, there is a significant negative association between driving experience and miscalibration (r = -.22; p <.001), the drivers who had less driving experience performed significantly worse on the Adaptation Test. The association between miscalibration and average mileage was negative and significant (r = -.13; p = .02), the drivers who had higher average mileage performed better on the Adaptation Test. Furthermore, there is a negative association between the Adaptation Test score and age (r = -.23; p <.001); the younger drivers performed worse on the Adaptation Test. The associations between the Adaptation Test, driving experience and average mileage were both negative (for driving experience r = -.13; p = .02 and for average mileage r = -.09; p = .11), indicating that the more experienced drivers performed better on the Adaptation Test (see Table 1). Spearman correlation coefficients

between the gender and the Adaptation Test or miscalibration showed there is a positive association between gender and miscalibration (r = .45; p <.001).

Table 1. *Pearson correlations between miscalibration, the Adaptation Test, driving experience and average mileage.*

	(1)	(2)	(3)	(4)	(5)
(1) Miscalibration	-	-.14*	-.22**	-.13*	-.05
(2) Adaptation Test		-	-.13*	-.09	-.23**
(3) Driving experience			-	.58**	-.13*
(4) Average mileage				-	.41**
(5) Age					-

*p<.05; **p<.001

Moreover, when controlling for gender, age, driving experience and average mileage, the association between miscalibration and the Adaptation Test remains a negative and significant one ($r_{partial}$ = -.12; p = .04).

The combined effect of age, gender and driving experience on behavioral adaptation *(see Table 2)*

In order to test the main effect of age on behavioral adaptation, we divided the drivers in four categories as a function of age, namely (1) drivers under 25 years, (2) ages ranging from 26 to 34, (3) ages ranging from 35 to 44, and (4) ages ranging from 45 to 54. The analysis of variance shows there is a main effect of age on the adaptation score (F (3, 254) = 6.66; p <.001; η^2_p = .07), the drivers under the age of 25 obtained a higher score on adaptation (M = 15.55) compared to those in the third age category (M = 12.86) or in the last category of age (M = 13.31). Moreover, the drivers in the second category (e.g. from 26 to 34 years old) obtained a higher score on the adaptation test (M = 15.41) compared to those in the third (M = 12.86) and fourth category of age (M = 13.31).

Moreover, there is a significant main effect of gender on the adaptation score (F (1, 254) = 6.27; p = .01; η^2_p = .02); the women (M = 13.44) obtained a lower score on adaptation compared to the men (M = 14.97).

In order to test the main effect of driving experience on adaptation we divided the drivers in two categories as a function of average mileage (e.g. those who had driven under 120,000 km were considered to be inexperienced drivers). The analysis of variance shows that there is a significant main effect of experience on the adaptation score (F (1, 254) = 9.57; p = .002; η^2_p = .03); the inexperienced drivers (M = 15.15) obtained a higher score on adaptation compared to the experienced drivers (M = 13.26).

Furthermore, there is an interaction effect of age and gender on adaptation (F (3, 254) = 4,78; p = .003; η^2_p = .05). Male drivers under the age of 25 (M = 15.53) obtained a significantly higher score on adaptation compared to the drivers with an age ranging from 35 to 44 years (M = 12.55); male drivers with an age ranging from 26 to 34 years (M = 17.51) obtained higher scores on adaptation compared to those in the third (M = 12.55) and fourth age category (M = 13.09). Moreover, male drivers aged from 26 to 34 years (M = 17.51) performed significantly better compared to women (M = 13.30) in the same age category.

The combined effect of age, gender, and driving experience on miscalibration *(see Table 2)*

Concerning the main effect of age on miscalibration, the results of variance analysis shows there is no main effect of age on miscalibration (F (3, 254) = .22; p = .87). There is a main effect of gender on miscalibration (F (1, 254) = 9.57; p = .003; η^2_p = .03). The women (M = 37.93) obtained a higher score on miscalibration compared to the men (M = 30.13). There is a combined effect of gender and driving experience on miscalibration (F (1, 254) = 5.39; p = .02; η^2_p = .02). The inexperienced women (M = 38.03) believe they know much more than in reality compared to the experienced women (M = 33.26). In the experienced drivers' group, there are significant differences between the women and men. The latter ones (M = 39.02) overestimated their knowledge to a higher level compared to the women (M = 26.60). Also, in the inexperienced drivers group, the women (M = 36.09) obtained a higher score on miscalibration compared to the men (M = 30.24).

Table 2. *The main effects of age, gender, driving experience and their combined effects on adaptation and miscalibration*

	Adaptation		**Miscalibration**	
Variables	F (η^2_p)	p	F (η^2_p)	p
Age	6.66 (.07)	**	.22 (.00)	*ns*
Gender	6.27 (.02)	*	9.57 (.03)	*
Driving experience	9.57 (.03)	*	1.13 (.00)	*ns*
Age * gender	4.78 (.05)	*	.77 (.01)	*ns*
Age * driving experience	.61 (.00)	*ns*	2.28 (.02)	*ns*
Gender * driving experience	.02 (.00)	*ns*	5.39 (.00)	*ns*

**p<.05; ** p<.001*

4. Discussions and conclusion

Through this study we managed to highlight an association between miscalibration and a driver's behavior adaptation in traffic. As previously shown, a miscalibrated driver, who tends to believe that they know more than in reality, has difficulties in adapting his/her behavior. As drivers move through the environment, they must identify the relevant information in changing traffic patterns and be prepared to react to events that may occur in order to avoid accidents. Our results support previous findings, showing that there is an association between age and behavioral adaptation, younger drivers having difficulties in adapting their speed due to traffic complexities (Davidse, Vlakveld, Doumen, & De Craen, 2010; Horswill & McKenna, 2004). Research on risk exposure of younger drivers indicates that they are more likely to speed than experienced drivers (Underwood, Crundall, & Chapman, 2002). The fact that drivers' performance may improve with practice may be due to increased automation in combination with improved self-assessment of skills, improved perception of the situation's complexityand as a result, adequate adaptation to task demands (Engstroem, Gregersen, Hernetkoski, Keskinen, & Nyberg, 2003; Tronsmoen, 2008).

Several previous studies showed that there is an association between gender and self-assessment of skills, indicating women to be less confident compared to men when they evaluate their own driving skills (Gregersen & Nyberg, 2002; Lajunen, Parker & Stradling, 1998) whereas other studies do not support these findings (Lajunen & Summala, 1995). In our study, we found out that women are more overconfident than men, which is consistent with the results obtained by Harré, Foster and O'Neill (2005) with regard to women overestimating obeying the traffic rules. We suppose that due to the fact that women are perceived as being less skillful compared to men, the overestimation of skills may be a form to enhance self-esteem. Concerning behavioral adaptation, previous findings merge into the conclusion that men have more adaptable behavior (de Craen, 2010). In our study, men adapted their speed due to traffic complexity more frequently than women. Due to the fact that in 2014 more than 68% of the total drivers in Romania were men, this might be as a result to the fact that that men are more frequently present in traffic, facing a broader range of different situations.

With regard to driving experience, our findings suggest that inexperienced drivers adapt their behavior more than experienced drivers. This might be due to the fact that experienced drivers have been found to be significantly slower when it comes to hazardous perception than expert drivers and have a significantly smaller range of horizontal eye-movement, as an indicator of a less effective visual search (Crundall, Chapman, Phelps & Underwood, 2003). Also, previous studies showed that experienced drivers

appear to spend less time looking at hazardous features (e.g. such as pedestrians, parked vehicles) (Crundall, Chapman, France, Underwood & Phelps, 2005).

Regarding the limitations of this study, first of all, the behavioral adaptation test uses self-reported speed to measure adaptation to task demands, which is not the same as actual speed behavior. However, using reported speed enables complete control over the complexity level of the traffic situation. Moreover, despite explicit instructions that the speed limit in traffic situations should be ignored, reported speed often fluctuated around the speed limit. This being said, increasing the difference between the simple and complex scenario could lead to more reported differences between the versions of the traffic situation.

Errors in calibration have important implications for safety and performance and can be due to deficiencies in the processing of available information, errors in evaluated self-competence and/or comparison errors. The failure to process highly critical information can result in an erroneous awareness of the situation (Griffin & Tversky, 1992). Similarly, an unrealistic appraisal of own skills and abilities can also place individuals in situations that they are ill-equipped to deal with. We consider our findings to be valuable mostly in the field of drivers' training. Due to the fact that an inadequate calibration can be the result of insufficient risk awareness and overconfidence, drivers' training should emphasize on correctly identifying dangerous situations and acknowledging cognitive biases that could lead to overestimating ones skills.

References

Biais, B., Hilton, D., Mazurier, K., & Pouget, S. (2005). Judgmental overconfidence, self-monitoring, and trading performance in an experimental financial market. *The Review of economic studies*, *72*(2), 287-312.

Clarke, D. D., Forsyth, R., & Wright, R. (2005). A statistical profile of road accidents during cross-flow turns. *Accident Analysis & Prevention*, *37*(4), 721-730.

Crundall, D., Chapman, P., Phelps, N., & Underwood, G. (2003). Eye movements and hazard perception in police pursuit and emergency response driving. *Journal of Experimental Psychology: Applied*, *9*(3), 163.

Crundall, D., Chapman, P., France, E., Underwood, G., & Phelps, N. (2005). What attracts attention during police pursuit driving?. *Applied cognitive psychology*, *19*(4), 409-420.de Craen, S., Twisk, D. A., Hagenzieker, M. P., Elffers, H., & Brookhuis, K. A. (2008). The development of a method to measure speed adaptation to traffic complexity: Identifying novice, unsafe, and overconfident drivers. *Accident Analysis & Prevention*, *40*(4), 1524-1530.

Davidse, R. J., Vlakveld, W. P., Doumen, M. J. A., & de Craen, S. (2010).*State awareness, risk awareness of and calibration by road users: a literature study* (Vol. 2010, No. 2).

de Craen, S. (2010). *The X factor. A longitudinal study of calibration in young novice drivers* (Doctoral dissertation). The Netherlands TRAIL Research School: TRAIL Thesis Series T2010/2.

de Craen, S., Twisk, D. A. M., Hagenzieker, M. P., Elffers, H., & Brookhuis, K. A. (2011). Do young novice drivers overestimate their driving skills more than experienced drivers? Different methods lead to different conclusions. *Accident analysis & prevention*, *43*(5), 1660-1665.

Engström, I., Gregersen, N. P., Hernetkoski, K., Keskinen, E., & Nyberg, A. (2003). Young novice drivers, driver education and training. *Literature Review. VTI Report A*, *491*.

Fuller, R. (2005). Towards a general theory of driver behavior. *Accident Analysis & Prevention*, *37*(3), 461-472.

Gregersen, N. P. (1996). Young drivers' overestimation of their own skill—an experiment on the relation between training strategy and skill. *Accident Analysis & Prevention*, *28*(2), 243-250.

Gregersen, N. P., & Nyberg, A. (2002). Privat Övningskörning. En Undersökning om Hur Den Utnyttjas och om Dess För- och Nackdelar för Trafiksäkerheten. VTI-report 481. Swedish Road & Traffic Research Institute, Linköping.

Griffin, D., & Tversky, A. (1992). The weighing of evidence and the determinants of confidence. *Cognitive psychology*, *24*(3), 411-435.

Harré, N., Foster, S., & O'Neill, M. (2005). Self-enhancement, crash-risk optimism and the impact of safety advertisements on young drivers. *British Journal of Psychology*, *96*(2), 215-230.

Hatakka, M., Keskinen, E., Gregersen, N. P., Glad, A., & Hernetkoski, K. (2002). From control of the vehicle to personal self-control; broadening the perspectives to driver education. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*(3), 201-215.

Horswill, Mark S. and McKenna, Frank P. (2004). Drivers' hazard perception ability: Situation awareness on the road. In Simon Banbury and Sebastien Tremblay (Ed.), *A cognitive approach to situation awareness: Theory and application* 1st ed. (pp. 155-175) UK: Ashgate Publishing, Ltd.

Kuiken, M., & Twisk, D. (2001). Safe driving and the training of calibration. *SWOV Institute for Road Safety Research, Leidschendam*.

Lajunen, T., & Summala, H. (1995). Driving experience, personality, and skill and safety-motive dimensions in drivers' self-assessments. *Personality and Individual Differences*, *19*(3), 307-318.

Lajunen, T., Parker, D., & Stradling, S. G. (1998). Dimensions of driver anger, aggressive and highway code violations and their mediation by safety orientation in UK drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *1*(2), 107-121.

Milech, D., Glencross, D., & Hartley, L. (1989). *Skills acquisition by young drivers: perceiving, interpreting and responding to the driving environment* (No. MR4).

Mynttinen, S., Sundström, A., Koivukoski, M., Hakuli, K., Keskinen, E., & Henriksson, W. (2009). Are novice drivers overconfident? A comparison of self-assessed and examiner-assessed driver competences in a Finnish and Swedish sample. *Transportation research part F: traffic psychology and behavior*, *12*(2), 120-130.

Nyberg, A., & Gregersen, N. P. (2007). Practicing for and performance on drivers' license tests in relation to gender differences in crash involvement among novice drivers. *Journal of safety research*, *38*(1), 71-80.

Özkan, T., Lajunen, T., Chliaoutakis, J. E., Parker, D., & Summala, H. (2006). Cross-cultural differences in driving skills: A comparison of six countries. *Accident Analysis & Prevention*, *38*(5), 1011-1018.

Sagberg, F., & Bjørnskau, T. (2006). Hazard perception and driving experience among novice drivers. *Accident Analysis & Prevention*, *38*(2), 407-414.

Spolander, K. (1983). *Drivers' assessment of their own driving ability* (No. VIT Rapport 252).

Sundström, A. (2008). Self-assessment of driving skill–A review from a measurement perspective. *Transportation Research Part F: Traffic Psychology and Behaviour*, *11*(1), 1-9.

Tronsmoen, T. (2008). Associations between self-assessment of driving ability, driver training and crash involvement among young drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *11*(5), 334-346.

Underwood, G., Crundall, D., & Chapman, P. (2002). Selective searching while driving: the role of experience in hazard detection and general surveillance. *Ergonomics*, *45*(1), 1-12.

World Health Organization. (2013). *WHO global status report on road safety 2013: supporting a decade of action*. World Health Organization.