

## Predictors of older drivers' looking behaviour when negotiating intersections

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### Abstract

The Driving Observation Schedule (eDOS) was developed for use in the Candrive/Ozcandrive five-year prospective study of older drivers to observe their driving behaviour. The aim of this study was to describe whether participants' looking behaviour when turning at intersections during the eDOS driving task was related to factors such as age, cognitive ability and complexity of the driving environment. One hundred and fifty-five Ozcandrive participants (Male: 71.4%; Age: M = 80.86 years, SD = 3.60 years) completed a cognitive and functional ability assessment from the Year 2 Candrive/Ozcandrive protocol, as well as the eDOS driving task that commenced from the participant's home and was conducted in their own vehicle on roads familiar to and chosen by them. Observations of participants' looking and driving behaviours during the eDOS driving task were captured from two cameras that were installed in participants' vehicle, which provided images of the driver and the forward road scene. For each turn at a four-way or T-intersection (n=981), participants' looking behaviour was coded as appropriate (e.g. left, right, ahead) or inappropriate using video recordings that were retrospectively reviewed by an observer. Other variables related to the complexity of driving environment were also coded. At 58 percent of the intersections, participants showed appropriate looking behaviour. Generalized estimating equations revealed that looking behaviour was significantly more appropriate at non-signalised intersections, when traffic volume was low and marginally significant more appropriate when turning right.

### Objective

In response to perceived age-related functional impairments, many older drivers employ self-regulatory strategies to keep themselves safe while driving (Ball et al., 1998; Hakamies-Blomqvist, 1994; Koppel et al., In press). However, when turning at intersections options to self-regulate are limited. One possibility to self-regulate when negotiating an intersection is to look appropriately and double-check the driving environment (Kostyniuk & Shope, 2003). The aim of this study was to explore older drivers' looking behaviour when turning at four-way or T-intersections during the Driving Observation Schedule (eDOS) driving task. Factors predicting appropriate looking behaviour when turning, such as age, gender, cognitive ability, functional ability, or the driving environment (e.g., complexity, weather etc.), were investigated.

### Methods

The eDOS driving task was developed for use in the Candrive/Ozcandrive prospective study of older drivers to observe their driving behaviour (Koppel et al., In press). The Candrive/Ozcandrive study is a longitudinal, multi-center international research program with the core objective of identifying solutions to promote older drivers' safe mobility (Marshall et al., 2013). The study involves 928 drivers aged 70 years and older in Canada and 302 drivers aged 75 years and older in Australia and New Zealand (Australia: n = 257; New Zealand: n = 45), who were recruited via media attention (newspaper, radio, television). Using a longitudinal study design, the project is tracking this cohort of older drivers for up to six years, assessing changes in their functional abilities, driving practices (e.g. exposure and patterns), as well as crashes and citations.

The eDOS driving task was conducted as part of the Year 2 Candrive/Ozcandrive protocol. It commenced from the participant's home, was conducted in their own vehicle on roads familiar to and chosen by them and lasted about 20 minutes. Participants' looking and driving behaviours during the eDOS driving task were captured from two cameras that were installed in the participants' vehicle at the commencement of the eDOS driving task, which provided images of the driver and the forward road scene. For each turn at a four-way or T-intersection, participants' looking behaviour was coded as appropriate or inappropriate. For T-intersections, looking behaviour was defined as appropriate if the participant looked at least one time to the left and one time to the right; at four-way intersections, looking behaviour was defined as appropriate if the participant looked at least one time to the left, one look to the right and one look straight ahead. Other variables related to the driving environment, like type of intersection (signalised or not signalised), traffic volume (no, low, moderate-high) or weather (clear, cloudy, rainy) were also coded. Additionally, participants underwent comprehensive evaluations as part of the Year 2 Candrive/Ozcandrive annual assessment including a cognitive assessment (Montreal Cognitive Assessment (Nasreddine et al., 2005)) and measurements of functional abilities, including the Snellen test for visual acuity (Currie, Bhan, & Pepper, 2000) and the Marottoli method for measuring neck rotation (Marottoli et al., 1998).

## Results

All Ozcandrive participants were approached to participate in the eDOS driving task, however, due to technical difficulties, only 227 participants (Male: 70%; Age: M = 81.53 years, SD = 3.37 years) completed the task. The video data of 155 participants (Male: 71.4%; Age: M = 80.86 years, SD = 3.60 years) who crossed 981 intersections were analysed retrospectively by a trained observer. Due to deficiencies of one or both cameras or low video quality, the eDOS video data of 72 participants (32%) could not be analysed.

Participants turned at 408 (32%) signalised and 573 (58%) non-signalised intersections. At 529 (54%) intersections a right turn was completed and at 452 (46%) a left turn was completed. Appropriate looking behaviour was shown at 571 intersections (58%). Table 1 presents an overview of the proportion of appropriate and inappropriate looking behaviour for different turning directions and different types of intersection.

*Table 1. Overview of percentage and number of appropriate and inappropriate looking behaviour when turning left or right at signalised or non-signalised intersections.*

	Signalised intersections		Non-signalised intersections		Total
	Left turn % (N)	Right turn % (N)	Left turn % (N)	Right turn % (N)	
<b>Appropriate looking</b>	3 (26)	2 (22)	26 (256)	27 (267)	58 (571)
<b>Inappropriate looking</b>	128 (128)	24 (232)	4 (42)	1 (8)	42 (410)
<b>Total</b>	16 (154)	26 (254)	30 (298)	28 (275)	100 (981)

A Logistic Generalised Estimating Equations Model was conducted to investigate the factors that predict older drivers' appropriate looking behaviour when turning at intersections during the eDOS driving task. This model revealed two significant (type of intersection and traffic volume) and one marginally significant (turn direction) predictors of the appropriateness of older drivers' looking behaviour. The strongest predictor was the type of intersection: At non-signalised intersections, older drivers were 72.68 times more likely to look appropriately compared to at signalised intersections ( $p < .001$ ). When the traffic volume was moderate to high, older drivers were 53 percent less likely to look appropriately compared to when there was no traffic volume ( $p = .025$ ). There was no significant difference in the appropriateness of looking behaviour when comparing low traffic volume with no traffic volume ( $p = .769$ ). When turning right, older drivers tended to be 1.52 times more likely to look appropriately compared to when turning left ( $p = .057$ ). Factors such as age, gender, cognitive ability, functional abilities (e.g., neck rotation, visual acuity), and weather did not influence the appropriateness of looking behaviour significantly.

## Discussion

The aim of this study was to explore older drivers' looking behaviour and to investigate factors which predict appropriate looking behaviour of older drivers when turning at an intersection. The type of intersection was significantly related to participants' appropriate looking behaviour. Interestingly, participants were significantly less likely to look appropriately at signalised intersections compared to non-signalised intersections. One potential reason for this finding is that older drivers may perceive turns at signalised intersections as low risk maneuvers and therefore just start driving without looking appropriately in each direction. However, crash data reveals a high number of crashes that occur at signalised intersections (Chen, Cao, & Logan, 2012), with unexpected red-light runners posing a high crash risk. Indeed, according to an estimation by Victoria Police (2009), 20 percent of all casualty crashes at large signalised intersections in Melbourne are due to red light running, highlighting the need for drivers to check the driving environment and not to trust in the traffic light unconditionally.

Traffic volume was another significant predictor of appropriate looking behaviour: When turning at an intersection with moderate to high traffic volume – especially on the intersection leg the driver wants to turn on to, older drivers were less likely to look appropriately compared to when turning on to a road without any traffic. One potential reason for this finding is that with the increased waiting time associated with higher traffic volume, drivers may become impatient and the acceptable gap size decreases (Hamed, Easa, & Batayneh, 1997; Polus, Lazar, & Livneh, 2003). With that, time to look appropriately decreases and cognitive workload increases (Hakamies-Blomqvist, 1994). Research shows that older driver crashes are more likely to occur during complex driving maneuvers where the cognitive demands exceed their cognitive abilities, leading to cognitive overload and leading them to make errors in the driving task (e.g., choosing an unsafe gap size) (Eberhard, 2007). In addition, older drivers were marginally more likely to look appropriately when turning right, the more complex condition, compared to when turning left. One explanation for this finding is that older drivers may be aware of the risk of right turns (i.e., having to make a safe gap selection etc.) and compensate by checking the driving environment more thoroughly. Indeed, previous research suggests that many older drivers avoid making right-turns while driving because of the perceived complexity (Ball et al., 1998; Charlton et al., 2006).

Older drivers' looking behaviour was not significantly predicted by age, gender, cognitive and functional abilities or weather. Contrary to previous research which has reported that lower cognitive and functional abilities are associated with reduced driving performance (Devlin, McGillivray, Charlton, Lowndes, & Etienne, 2012; Wadley et al., 2009) and higher crash risk (Owsley et al., 1998), there were no significant relationships between these factors and appropriate looking behaviour revealed in this study.

## Limitations

Some limitations of the study are noted. First, head movements were coded as a proxy for looking behaviour. The coding depended on the subjective judgement of the trained observer and very minor head movements may not have been counted. Similarly, no statement can be made about eye movements (saccades and fixations) or attentional processes. These factors should be explored in further research. Second, the analyses are based on videos from an on-road driving task from the Ozcandrive cohort study with a convenience sample of independent, healthy older drivers who made a commitment to participate in a longitudinal study, and therefore the results may not be generalisable to all older drivers.

## Conclusion

Not all older drivers looked appropriately while turning at a T- or four-way intersection. Appropriate looking behaviour was predicted by the type of intersection, traffic volume and turning direction. Taken together, these findings suggest that the awareness of risks at signalised intersections and the need to check the environment while negotiating an intersection should be raised. Additionally, the study

revealed that not personal variables but road environmental ones affect older drivers' looking behaviour at intersections.

## References

- Ball, K., Owsley, C., Stalvey, B., Roenker, D. L., Sloane, M. E., & Graves, M. (1998). Driving avoidance and functional impairment in older drivers. *Accident Analysis & Prevention*, *30*(3), 313-322.
- Charlton, J. L., Oxley, J., Fildes, B., Oxley, P., Newstead, S., Koppel, S., & O'Hare, M. (2006). Characteristics of older drivers who adopt self-regulatory driving behaviours. *Transportation Research Part F: Traffic Psychology and Behaviour*, *9*(5), 363-373.
- Chen, H., Cao, L., & Logan, D. B. (2012). Analysis of Risk Factors Affecting the Severity of Intersection Crashes by Logistic Regression. *Traffic Injury Prevention*, *13*(3), 300-307. doi: 10.1080/15389588.2011.653841
- Currie, Z., Bhan, A., & Pepper, I. (2000). Reliability of Snellen charts for testing visual acuity for driving: prospective study and postal questionnaire. *BMJ*, *321*(7267), 990-992.
- Devlin, A., McGillivray, J., Charlton, J., Lowndes, G., & Etienne, V. (2012). Investigating driving behaviour of older drivers with mild cognitive impairment using a portable driving simulator. *Accid Anal Prev*, *49*, 300-307. doi: 10.1016/j.aap.2012.02.022
- Eberhard, J. (2007). *Do older drivers have a heightened crash risk? Licensing authorities' options for managing older driver safety: practical advice from the researcher*. Paper presented at the Transportation Research Board 86th Annual Meeting, Washington, DC.
- Hakamies-Blomqvist, L. (1994). Compensation in older drivers as reflected in their fatal accidents. *Accident Analysis & Prevention*, *26*(1), 107-112.
- Hamed, M., Easa, S., & Batayneh, R. (1997). Disaggregate gap-acceptance model for unsignalized T-intersections. *Journal of Transportation Engineering*, *123*(1), 36-42.
- Koppel, S., Charlton, J. L., Langford, J., Di Stefano, M., MacDonald, W., Vlahodimitrakou, Z., . . . Marshall, S. (In press). The relationship between older driver's performance on an on-road driving task, functional abilities, perceptions of driving comfort and abilities and self-reported driving restrictions. *The Canadian Journal of Aging*.
- Kostyniuk, L. P., & Shope, J. T. (2003). Driving and alternatives: Older drivers in Michigan. *Journal of Safety Research*, *34*(4), 407-414. doi: 10.1016/j.jsr.2003.09.001
- Marottoli, R. A., Richardson, E. D., Stowe, M. H., Miller, E. G., Brass, L. M., Cooney, L. M., & Tinetti, M. E. (1998). Development of a Test Battery to Identify Older Drivers at Risk for Self - Reported Adverse Driving Events. *J Am Geriatr Soc*, *46*(5), 562-568.
- Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., . . . Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc*, *53*(4), 695-699.
- Owsley, C., Ball, K., McGwin Jr, G., Sloane, M. E., Roenker, D. L., White, M. F., & Overley, E. T. (1998). Visual processing impairment and risk of motor vehicle crash among older adults. *Jama*, *279*(14), 1083-1088.
- Police, V. (2009). Safety Camera Program.
- Polus, A., Lazar, S. S., & Livneh, M. (2003). Critical gap as a function of waiting time in determining roundabout capacity. *Journal of Transportation Engineering*, *129*(5), 504-509.
- Wadley, V. G., Okonkwo, O., Crowe, M., Vance, D., Elgin, J., Ball, K., & Owsley, C. (2009). Mild cognitive impairment and everyday function: an investigation of driving performance. *Journal of geriatric psychiatry and neurology*.