Why drive manual? - Automatic transmission improves driving behaviour in older drivers

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Background

Driving in complex traffic environments leads to high workload, especially in traffic situations that require interaction with other road users, for example at T-junctions (Verwey, 2000). In these interactive situations, older drivers have less cognitive processing resources than younger drivers (Verwey, 2000). In fact, older drivers crash more frequently in complex traffic environments, e.g., in intersections that involve turning, especially turning across the oncoming lane, and in complex traffic situations, e.g., when overtaking and merging (Clarke, Forsyth, & Wright, 1998; Mayhew, Simpson, & Ferguson, 2006; McGwin & Brown, 1999). There have been contradictory results about older drivers' performance regarding tactical and operational driving skills, in accordance with the Michon hierarchy (Michon, 1985). While some claim younger drivers make more driving errors than their older counterparts (Carr, Jackson, Madden, & Cohen, 1992), older drivers have been found to have more problems with operational driving skills (Perryman & Fitten, 1996). This paper focuses on one particular operational driving skill, namely gear changing, which is often seen as an automatized task (Baddeley, 2006; Michon, 1985). For a novice driver, gear changing can be difficult and will not be automatized until it is overlearned after increasing practice (Shinar, Meir, & Ben-Shoham, 1998). However, for older drivers the execution of motor skills can become less automatized than previously (Brouwer & Ponds, 1994), which could affect gear changing. In a previous study, inappropriate gears changes were found to be the fourth most common driving error in older drivers (Selander, Lee, Johansson, & Falkmer, 2010). However, it remains unknown how transmission type affects driving behaviour and whether or not a car with automatic transmission enhances safe driving. The aim of

the present study was thus to investigate whether a car with automatic, compared with manual, transmission improves driving behaviour in older drivers.

Method

In order to achieve the objective of this study, a younger group of drivers was used as a control group. The study was approved by a local Ethical Committee in Gothenburg, Sweden. The data were collected in a driving assessment unit in Sweden.

Participants

The participants were recruited via the Vehicle Registration Office, local senior organizations and local businesses. Invitation letters were sent to potential participants explaining the purpose of the study. In total, 63 drivers agreed to participate in the study. The two groups were the older driver group (n=31, 42% women) and the younger driver group (n=32, 44% women). The older group's mean age was 75.2 (SD=4.9, ranging from 70-90 yrs) and the younger group's mean age was 39.2 (SD=5.2, ranging from 27-48 yrs). The younger group did not comprise any novice drivers. All older participants currently owned and drove manual transmission cars. Twenty-eight participants in the younger group owned and drove manual transmission cars, while four participants owned automatic transmission cars. All participants had a valid driving licence for manual transmission.

Procedures

The participants were assessed twice on the same fixed route; once in a car with manual transmission and once in a car with automatic transmission, in a randomly allocated balanced order. Every second participant in both groups started with the manual transmission car and continued immediately after with the automatic transmission car. The cars were identical except for the transmission type, i.e., the same car make (Volvo V50), model year. Both cars were equipped with dual controls. Each driving test took approximately 35 minutes on public roads in a suburban district in right hand side traffic. The route comprised a diversity of intersections, right and left turns, roundabouts and road signs. A driving assessor (a specially trained occupational therapist) assessed the drivers' behaviour, e.g., how they followed instructions, manoeuvred, managed lane positioning, obeyed traffic rules, interacted with other road users, and their attention. Their behaviour was noted on a Ryd On-road Assessment (ROA) driving protocol scoring sheet, further presented below. A driving instructor had the safety responsibility (dual controls) and gave directions to follow throughout the route. The driving instructor sat in the front passenger seat and the driving assessor in the back seat to the right. The time it took to complete predefined left turns was measured.

Driving assessment measurements

i. ROA-protocol:

ROA was developed and is utilised clinically at the driving assessment unit where the tests took place (Selander et al., 2010). The scoring sheet comprises 34 specified items in seven categories, i.e., speed, position, attention, indicator, manoeuvring, instructions, and traffic rules, as shown in Figure 1. Errors made are graded on a 0-2 scale, where 0 implies normal driving behaviour, 1 indicates minor error, while 2 indicates considerable risk-taking behaviour. There is no upper limit to the scores.

ii. Intersections - left turns:

At three intersections, the instruction was to turn left after a complete stop from a feeder road into a trunk road with priority. From the driving instructor's word of command when free access was given to the trunk road, the drivers started to drive and the time (in seconds) was measured to a specific point (mean 68 m) on the trunk road.

Statistical analyses

Statistical analyses were performed using SPSS® (version 17.0). All variables were tested for normal distribution with the use of the Kolmogorov-Smirnov test. Wilcoxon signed rank tests, Mann-Whitney *U*-tests, and paired samples and independent samples student's *t*-tests were used with the α-level set at .05. Cohen's *d* was calculated where applicable.

Results

As shown in Table 1, the older group demonstrated more driving errors, both in the car with manual transmission and in the automatic transmission car compared with the younger group, (Cohen's $d = 0.94$).

Table 1. Driving measurements for the manual and automatic transmission car conditions, and for the older and the younger group, respectively. (s) = seconds, CI=Confidence Intervals.

Mean values	**Older group (n=31)**	**Within group *p*-values**	**Younger group (n=32)**	**Within group *p*-values**	**Between groups *p*-values**
Driving errors (Manual)	24.3 *95% CI = 19.0-29.7*	p < .001*	6.2 *95% CI = 4.8-7.5*	p = .21	p < .001*
Driving errors (Automatic)	10.6 *95% CI = 8.1-13.1*		5.4 *95% CI = 3.9-6.9*		p = .001*
Left turns (s) (Manual)	12.8 *95% CI = 12.3-13.4*	p = .003*	11.9 *95% CI = 11.5-12.2*	p = .001*	p = .004*
Left turns (s) (Automatic)	11.9 *95% CI = 11.5-12.2*		11.4 *95% CI = 11.0-11.7*		p = .036*

* indicates significant differences.

The younger group performed the left-turns in shorter time than the older group in the manual transmission car (Cohen's *d* = 0.78), as well as in the automatic transmission car (Cohen's *d* = 0.54).

In the older group, driving the automatic transmission car improved their driving behaviour regarding the number of driving errors and during the turning left-task (Cohen's *d* = 0.60), compared with when they drove the manual transmission car. However, the car with automatic transmission did not affect the driving behaviour for the younger group, except for the turning left-task (Cohen's *d* = 0.67).

The automatic transmission car had a positive impact on the driving behaviour of the older group in five driving items within the ROA-protocol. The two showing the largest impacts were *Manoeuvring – Change gear* (p < .001), indicating inappropriate gear usage and *Speed-Too fast for the situation* (p < .001), relating to problems with controlling the speed according to the situation. The other three items were *Manoeuvring – Handling pedals* (p = .005), *Traffic rules –Exceeding speed limit* (p = .010), and *Position – To the left* (p = .027).

1.Speed	2.Position	3.Attention	4.Indicator	5.Manouvering	6.Instructions	7.Traffic rules
Too fast for the situation	To the right	To the right	No use of indicator	*Handling pedals*	Repeating needed	Give right of way
Too slow for the situation	*To the left*	To the left	Wrong direction	Steering	Reminding needed	Yield to traffic
Slow/late braking	Close to the vehicle in front	Ahead	Too late	*Change gear*	Drive the wrong way	Obligation to stop
Braking without reason	Sway between lanes	To the rear incl. rear-view mirror	Too early	Manage controls to the left		*Exceeding speed limit*
		Blind spot, to the right	Does not switch it off	Manage controls to the right		Rules regarding buses
		Blind spot, to the left		Reverse		Crossing a solid lane line

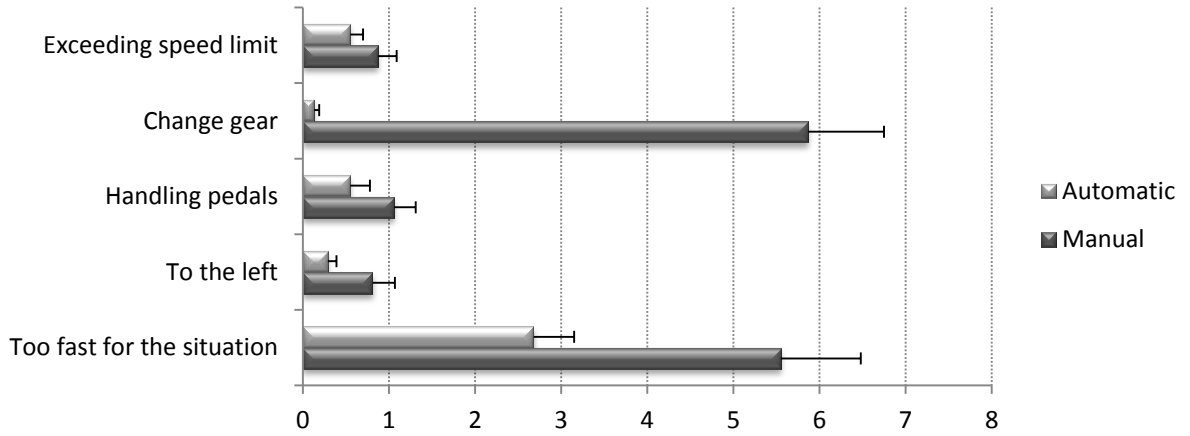

Figure 1. The ROA (Ryd On-road Assessment) protocol. Items indicated in italics were the ones in which the automatic transmission car had a significantly positive impact for the older group, which is further displayed in the bar chart in the lower part of the figure. The X-axis represents the average number of errors and the error bars display the positive SE of the mean.

Discussion

The present study found that the older participants' driving behaviour improved when driving a car with automatic transmission. As a result of the automatic transmission they displayed safer speed adjustments in urban areas, safer lane positioning, greater manoeuvring skills and better attention to the speed regulations. Furthermore, their left turns improved by driving a car with automatic transmission. These results are consistent with other results, suggesting that manual gear changing is not an entirely automatized process (Shinar et al., 1998), but in contrast

to other findings (Ranney, 1994). Contrary to our findings in the older group, automatic transmission had only a minor effect on the driving behaviour of the younger group. As a matter of fact, the only effect of automatic transmission was on their left turns.

The present study measured driving errors as an outcome variable. Driving errors are defined as "…*unwanted results of involuntary actions whereas violations are conscious deviation from a rule or safe practice* (Ozkan, Lajunen, Chliaoutakis, Parker, & Summala, 2006, p. 228). Driving errors are thought to diminish with experience (Evans, 2004). However, experienced drivers may actually display driving behaviours that can be dangerous (Summala, 2000). Improved driving skills do not always indicate error-free driving behaviour. Instead, there are different types of errors, with different kinds of implications (Stanton & Salmon, 2009). Some driving errors do not disappear with experience and age. They may, actually, have become an habitual part of the driving behaviour over many years for some older drivers (Reason, Manstead, Stradling, Baxter, & Campbell, 1990; Selander et al., 2010). In the present study, certain driving errors were more common than others in the older drivers group, e.g., speed adjustment and positioning, and these errors do predict crashes in older drivers (Braitman, Kirley, Ferguson, & Chaudhary, 2007; Classen, Shechtman, Awadzi, Joo, & Lanford, 2010). Furthermore, and similar to our findings, Reason and colleagues found frequent driving errors regarding gear changing (Reason et al., 1990).

Several studies have reported that older drivers self-regulate their driving in certain driving situations, for example by driving slower or by reducing the time and distance driven (Owsley, 2002; Unsworth, Wells, Browning, Thomas, & Kendig, 2007). Moreover, older drivers seem to compensate for distractions by driving slower in complex traffic environments (Horberry, Anderson, Regan, Triggs, & Brown, 2006). As shown in Figure 1, a frequent driving error identified in the present study was that the older drivers drove faster than appropriate for the traffic situation. They might not have exceeded the speed limits, but their speed was deemed too high for the actual situation e.g., when meeting vulnerable road users, crossing an intersection or driving through roundabouts. Driving requires simultaneous use of central and peripheral vision (Owsley & McGwin, 2010). To determine speed, the main cue is the peripheral vision (Evans, 2004), which is important for safe driving (Owsley & McGwin, 1999). Deterioration in visual functions may be a risk factor for crashes in older adults (Owsley & McGwin, 1999).The inherent deterioration of the peripheral vision in humans while aging may actually be an explanation for our results. Correlations between decreased vision and speeding errors found in previous research support this suggestion (Baldock, Berndt, & Mathias, 2008).

As an age-group, our younger group was, in fact, "middle-aged". This group constitute the safest age cohorts of drivers (Evans, 2004). Thus, it comes as no surprise that the automatic transmission car had no major effect on their driving behaviour. Compared with the older drivers, they had fewer driving errors with both

the manual transmission car and the automatic transmission car. Apparently, possible distraction from manual gear shifting was small enough not to be detected by the driver behaviour measurements this study utilised.

A limitation of this study was the relatively small sample size. Moreover, there was no measurement of intra-rater, inter-rater or test-retest reliability of the ROA protocol. Furthermore, there was a risk that biased scoring may have occurred, since the assessor - for obvious reasons - could not be blinded to the participants' group belonging.

Conclusions

Automatic transmission improved the older participants' driving behaviour by safer speed adjustments in urban areas, greater manoeuvring skills, safer lane positioning and driving according to the existing speed limits. However, for younger drivers, automatic transmission had less effect on their driving behaviour. Switching to automatic transmission may be recommended for older drivers as a means to maintain safe driving and thereby the quality of their transport mobility.

References

Baddeley, A. (2006). Working memory: an overview. In *Working memory and education*. London: Elsevier.

Baldock, M. R. J., Berndt, A., & Mathias, J. L. (2008). The functional correlates of older drivers' on-road driving test errrors. *Topics in Geriatric Rehabilitation, 24*(3), 204-223.

Braitman, K. A., Kirley, B. B., Ferguson, S., & Chaudhary, N. K. (2007). Factors leading to older drivers' intersection crashes. *Traffic Inj Prev, 8*(3), 267-274.

Brouwer, W. H., & Ponds, R. W. H. M. (1994). Driving competence in older persons. *Disability and Rehabilitation, 16*(3), 149-161.

Carr, D., Jackson, T. W., Madden, D. J., & Cohen, H. J. (1992). The effect of age on driving skills. *J Am Geriatr Soc, 40*(6), 567-573.

Clarke, D. D., Forsyth, R., & Wright, R. (1998). Behavioural factors in accidents at road junctions: the use of a genetic algorithm to extract descriptive rules from police case files. *Accid Anal Prev, 30*(2), 223-234.

Classen, S., Shechtman, O., Awadzi, K. D., Joo, Y., & Lanford, D. N. (2010). Traffic violations versus driving errors of older adults: informing clinical practice. *Am J Occup Ther, 64*(2), 233-241.

Evans, L. (2004). *Traffic Safety* (1 ed ed.): Bloomfield Hills: Science Serving Society.

Horberry, T., Anderson, J., Regan, M. A., Triggs, T. J., & Brown, J. (2006). Driver distraction: the effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. *Accid Anal Prev, 38*(1), 185-191.

Mayhew, D. R., Simpson, H. M., & Ferguson, S. A. (2006). Collisions involving senior drivers: high-risk conditions and locations. *Traffic Inj Prev, 7*(2), 117-124.

McGwin, G., Jr., & Brown, D. B. (1999). Characteristics of traffic crashes among young, middle-aged, and older drivers. *Accid Anal Prev, 31*(3), 181-198.
Michon, J. A. (1985). *A critical view of driver behaviour models: What do we know, what should we do?* New York: Plenum Press.
Owsley, C. (2002). Driving mobility, older adults and quality of life. *Gerontechnology, 1*(4), 220-230.
Owsley, C., & McGwin, G., Jr. (1999). Vision impairment and driving. *Surv Ophthalmol, 43*(6), 535-550.
Owsley, C., & McGwin, G., Jr. (2010). Vision and driving. *Vision Res, 50*(23), 2348-2361.
Ozkan, T., Lajunen, T., Chliaoutakis, J. E., Parker, D., & Summala, H. (2006). Cross-cultural differences in driving skills: a comparison of six countries. *Accid Anal Prev, 38*(5), 1011-1018.
Perryman, K. M., & Fitten, L. J. (1996). Effects of normal aging on the performance of motor-vehicle operational skills. *J Geriatr Psychiatry Neurol, 9*(3), 136-141.
Ranney, T. A. (1994). Models of driving behavior: a review of their evolution. *Accid Anal Prev, 26*(6), 733-750.
Reason, J., Manstead, A., Stradling, S., Baxter, J., & Campbell, K. (1990). Errors and violations on the roads: a real distinction? *Ergonomics, 33*(10/11), 1315-1332.
Selander, H., Lee, H. C., Johansson, K., & Falkmer, T. (2010). Older drivers: on-road and off-road results. *Accid Anal Prev, 43* (2011) 1348–135.
Shinar, D., Meir, M., & Ben-Shoham, I. (1998). How automatic is manual gear shifting? *Hum Factors, 40*(4), 647-654.
Stanton, N. A., & Salmon, P. M. (2009). Human error taxonomies applied to driving: A generic driver error taxonomy and its implications for intelligent transport systems. *Safety Science, 47*, 227-237.
Summala, H. (2000). Automatization, automation, and modeling of driver's behavior. *Recherche - Transports - Sécurité, 66*, 35-45.
Unsworth, C. A., Wells, Y., Browning, C., Thomas, S. A., & Kendig, H. (2007). To continue, modify or relinquish driving: findings from a longitudinal study of healthy ageing. *Gerontology, 53*(6), 423-431.
Verwey, W. B. (2000). On-line driver workload estimation. Effects of road situation and age on secondary task measures. *Ergonomics, 43*(2), 187-209.