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# Interaction between visual status, driver age and distracters on daytime driving performance ☆

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ABSTRACT

This study investigated the effects of visual status, driver age and the presence of secondary distracter tasks on driving performance. Twenty young ($M = 26.8$ years) and 19 old ($M = 70.2$ years) participants drove around a closed-road circuit under three visual (normal, simulated cataracts, blur) and three distracter conditions (none, visual, auditory). Simulated visual impairment, increased driver age and the presence of a distracter task detrimentally affected all measures of driving performance except gap judgments and lane keeping. Significant interaction effects were evident between visual status, age and distracters; simulated cataracts had the most negative impact on performance in the presence of visual distracters and a more negative impact for older drivers. The implications of these findings for driving behaviour and acquisition of driving-related information for people with common visual impairments are discussed.



## 1. Introduction

Effectively interacting with the visual environment requires successful integration of complex information from a variety of sources. Age-related changes in sensory abilities, such as visual impairment, can potentially compound this process and influence not only the ability to undertake visual tasks, but also to complete simultaneous secondary tasks not directly related to vision, such as walking through the environment and driving. Evidence from the literature supports this assertion, where both simulated and true visual impairment have been shown to reduce postural stability (Anand, Buckley, Scally, & Elliott, 2003; Schwartz et al., 2005; Wood et al., 2009) and impair mobility and gait performance (Elliott, Patla, Furniss, & Adkin, 2000; Patel et al., 2006; Turano et al., 2004). Visual impairment is also associated with increased falls risk among older adults (Coleman et al., 2007; Ivers, Cumming, Mitchell, & Attebo, 1998; Klein, Moss, Klein, Lee, & Cruickshanks, 2003).

Visual impairment has been shown to contribute to the driving difficulties of older adults. Indices of unsafe driving performance, including increased crash risk and impaired on-road driving performance, have been reported in older drivers with cataracts (Owsley, Stalvey, Wells, & Sloane, 1999; Owsley, Stalvey, Wells, Sloane, & McGwin, 2001; Wood & Carberry, 2006) and glaucoma (Haymes, Leblanc, Nicolela, Chiasson, & Chauhan, 2007; Haymes, LeBlanc, Nicolela, Chiasson, & Chauhan, 2008; McGwin et al., 2005; Owsley, McGwin, & Ball, 1998) and in those drivers with reductions in specific visual functions including visual fields, motion sensitivity, contrast sensitivity and visual attention (Owsley & McGwin, 1999; Wood, 2002).

Visual impairment is likely to exacerbate existing deteriorations in physical and cognitive ability and judgment. More specifically, for the visually impaired, the ability to perform concurrent tasks may be compromised because the processing and interpretation of visual input may represent a significant attention demanding task in itself. There is some evidence to suggest that this may be the case. Turano, Geruschat, and Stahl (1998) reported that the mobility problems of visually impaired individuals were exacerbated compared to controls when participants were required to undertake a secondary auditory task.

The driving situation and the in-vehicle environment are also becoming increasingly complex. Some vehicles are equipped with sophisticated in-vehicle navigation and information systems as well as entertainment systems, which, like mobile phones, add to the driver's attentional burden potentially distracting them from their primary task. Recent laboratory-based studies demonstrated that the combination of visual and auditory distracters reduces the extent of the useful field of view (Wood et al., 2006), which has been shown to be linked to crash rates in older drivers (Owsley et al., 1998).

The aims of this study were to investigate the effects of visual status, age and distracters on real-world measures of daytime

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driving performance and to develop an understanding of the interactions between these factors. In particular, the interaction between simulated visual impairment and secondary tasks on visually guided behaviours such as driving is unknown and is of particular interest given the increasing complexity of both the in-vehicle and driving environment.

## 2. Methods

### 2.1. Participants

Participants included 20 younger (mean age 26.8 ± 4.7 years; range 19–34 years; 7 women and 13 men) and 19 older (mean age 70.21 ± 5.0 years; range 63–78 years; 9 women and 10 men) individuals with normal corrected vision, who were free of ocular pathology and were in good general health. Participants were screened for visual, auditory and cognitive impairment. All participants had visual acuity within normal limits for their age, normal hearing sensitivity as defined by pure tone hearing threshold levels in both ears, lower than or equal to 20 dB at octave frequencies between 500 Hz and 4000 Hz and scored 24 or more on the Mini-Mental State Exam (Folstein, Robbins, & Helzer, 1983).

The study was conducted in accordance with the requirements of the Queensland University of Technology Human Research Ethics Committee. All participants were given a full explanation of the experimental procedures and written informed consent was obtained, with the option to withdraw from the study at any time.

### 2.2. Procedure

Driving performance was assessed under the baseline normal vision condition, where participants drove with their optimum distance refractive correction, and two simulated visual impairment conditions, one of which was designed to simulate the effects of cataracts and the other represented optically blurred vision. All of the visual conditions were incorporated into full aperture lenses and were mounted in modified goggles together with each participant's distance refractive correction normally worn for driving. The cataract goggles have been used in previous vision and driving studies and result in moderate reductions in visual acuity, to an average level of approximately 20/40 (the minimum level of visual acuity for driver licensure in Australia) and reductions in contrast sensitivity at both high and low spatial frequencies (Higgins & Wood, 2005; Wood & Troutbeck, 1994). The goggles do not restrict the binocular field of view below driver licensing standards in Australia of a horizontal extent of 120°. For the blurred vision condition, binocular plus lens blur was used to reduce the distance visual acuity of each participant individually to match as closely as possible (in 0.25 dioptre steps) that obtained when they were wearing the cataract simulation goggles. This allowed us to explore the relative effects of simulated cataracts and blur on driving performance when visual acuity was matched, and the interactions with age and distracters.

For each visual condition, both visual acuity and contrast sensitivity were measured binocularly. Distance high contrast visual acuity was assessed under standard illumination conditions using a logMAR Bailey Lovie Chart, at a viewing distance of 3.0 m and scored on a letter by letter basis. Contrast Sensitivity (CS) was measured using the Pelli-Robson chart under the recommended viewing conditions. Participants were instructed to look at a line of letters and asked to guess the letter when they were not sure; each letter reported correctly was scored as 0.05 log units.

Driving performance was assessed in a right hand drive, mid-size sedan (Nissan Maxima) which was instrumented and had automatic transmission and power steering. Performance was measured under daytime conditions on a 5.1 km bitumen driving circuit, which consisted of hills, curves, straight sections, intersections and signage and was free of other vehicles and representative of rural roads (Wood & Troutbeck, 1994). A number of additional roadway objects were introduced to the circuit to obtain the following measures of driving performance (Wood, 2002). Sign recognition: participants were instructed to report the identity of 42 standard signs containing 65 items of information as they drove around the circuit. Hazard avoidance: participants were required to report and avoid hitting any of nine, large low contrast foam hazards (220 cm × 80 cm × 15 cm) positioned along the roadway; the locations of which were randomized between trials. Gap judgment: nine pairs of traffic cones of variable lateral separation were positioned throughout the course, with equal numbers being set to be wide enough, not wide enough and just wide enough for the car to pass through; the separation of cone pairs varied between trials. Participants were required to report whether the cone gap was wide enough to drive through and if so, to do so; if the gap was judged to be too narrow they were instructed to drive around the cones. Performance was scored in terms of whether the judgments were correct. Lane keeping: this was recorded by two video cameras mounted on the vehicle roof and scored post-testing as the percentage of time that the vehicle was outside of the lane. Lane crossings where the participant was responding to a hazard on the road were not included. Driving time: time to complete the road course was also recorded.

Participants were given a practice run in order to familiarize themselves with the car, the road circuit and the driving performance tasks, with and without the secondary visual and auditory tasks. The practice lap was performed in the opposite direction to the recorded run. Participants were instructed that they would be required to perform a number of tasks whilst driving at what they felt was a safe speed, to drive in their own lane except when avoiding hazards and to obey all regulatory signs.

The distracter task required the participants to verbally report the sum of pairs of numbers (i.e., "2 + 5") presented either via a dashboard-mounted monitor (visually) or through a computer speaker (auditorally) while driving (Chaparro, Wood, & Carberry, 2005). The monitor was positioned just left of the steering wheel on the dashboard. The visual distracters consisted of the simultaneous presentation of pairs of large single digit numbers subtending between 3.5° and 4.8° of visual angle, which were well above the visual threshold of all participants for all of the viewing conditions included in this study. The auditory stimuli were presented at a comfortable listening level set by each participant using an adaptive technique. Pairs of numbers were presented approximately every 3.5 s for a mean duration of between 3.5 and 4.0 s. Given that the time taken to complete each lap varied between testing conditions and individuals, the number of distracters presented also varied, that is, those who completed a lap more quickly were presented with less distracter tasks and vice versa. Performance measures for this secondary task were calculated as the percentage of distracters missed for each condition. The presentation of distracters was computer driven and because of their frequency coincided with participants avoiding road hazards, reporting signs and judging cone gaps. This is representative of commonly encountered in-vehicle distracters, such as mobile phones, which do not take account of what is happening in the driving environment.

Each participant drove around the circuit wearing each of the three visual conditions (baseline, simulated cataracts or blur) three times, once for each of the three distracter conditions (no distraction, visual distraction or auditory distraction). These nine combinations were randomized and the driving runs were conducted over two visits to the driving track separated by at least a week to minimize learning and fatigue effects.

### 2.2.1. Data analysis

A composite driving score was derived to capture the overall driving performance of the individual participants compared to the whole group as has been used in previous studies (Chaparro et al., 2005; Wood, 2002). The composite score included performance for sign recognition, gap perception, course time and the number of hazards hit. Z scores for each of these four driving measures were determined and the mean Z score for each participant calculated to provide a composite score (the data were transformed where necessary to ensure that better performance was always represented by a more positive Z score).

The data were analysed using a series of repeated measures ANOVAs with two within subjects factors (visual condition and distracter condition) and one between subjects factor (age). All possible interactions were considered in the analysis and all significant main effects or simple main effects were investigated using Fishers' Least Significant Difference (LSD) test. After a significant *F* test, the LSD test examines all pairwise comparisons between means, while maintaining the family-wise error at the nominal alpha level (.05) provided there are three or fewer conditions to be compared, as was always the case for the present study (Howell, 1997; Ramsey, 1993). For the sake of brevity, only significant differences are described.

The hazards seen or avoided measure revealed a ceiling effect with several conditions, where all or almost all hazards were correctly seen and not hit. No separate component analyses were therefore performed for these measures. The time to complete the circuit data were significantly skewed, so a logarithmic transform was applied to achieve normal distribution; although the data are plotted in raw score form for simplicity of interpretation. The number of secondary task sums missed in each condition also showed some skew and heterogenous variances since there were usually only a small proportion of sums missed in each condition (ranging from 12% to 30%). This measure was therefore arcsine transformed as recommended for proportion data (Howell, 1997), although again the data are plotted in raw score form for simplicity of interpretation.

## 3. Results

Table 1 shows the mean visual acuity and contrast sensitivity of each age group under the different visual conditions. Visual acuity was reduced in both the blur and cataract conditions relative to the normal vision condition, with the younger participants showing a mean impairment in visual acuity of 0.28 logMAR for blur and 0.32 logMAR for cataract relative to baseline, and the older participants showing a mean impairment of 0.33 logMAR for blur and 0.36 logMAR for cataract relative to baseline. The reduction in visual acuity as a result of the goggles did not differ significantly between age groups ($t_{37} = -1.48$, $p = 0.148$ for blur, and $t_{37} = -1.53$, $p = 0.134$ for cataract). While the blurring lenses were selected to match the visual acuity degradation of the simulated cataracts, they resulted in only a modest reduction in contrast sensitivity, with a mean reduction in contrast sensitivity of −0.09 for the younger group and −0.12 for the older group. Conversely, the cataract simulation lenses markedly impaired contrast sensitivity with a mean difference of −0.68 for the younger group and −0.67 for the older group. Again, the change in contrast sensitivity as a result of the lenses did not differ significantly between age groups ($t_{37} = 0.84$, $p = 0.406$ for blur, and $t_{37} = -0.048$, $p = 0.962$ for cataract).

### 3.1. Overall driving score

There was a significant main effect of vision condition ($F_{2,74} = 135.67$, $p < 0.001$) such that, the composite driving score was significantly worse when participants drove with the blur or cataract simulations, and was significantly worse for the cataract compared to the blur condition. There was also a significant main effect of distracter condition ($F_{2,74} = 22.75$, $p < 0.001$), such that the overall driving score was significantly better for the no distracter condition compared to either the visual or auditory distracter conditions. The two distracter conditions were not significantly different from one another. There was also a significant interaction between vision condition and distracters ($F_{4,148} = 8.66$, $p < 0.001$). As shown in Fig. 1A, in both the normal and blur conditions there was a significant difference between the auditory distracter and single task condition and between the visual distracter and single task condition, but no significant difference between the auditory and visual distracter conditions. With the cataract simulation, there was a uniform drop in driving performance and the visual distracter condition resulted in significantly poorer performance than either the single task or auditory distracter.

There was a significant main effect of age for the composite driving score, in which the younger drivers performed significantly better than the older drivers ($F_{1,37} = 43.72$, $p < 0.001$) (Fig. 1B). There was also a significant vision by group interaction ($F_{2,74} = 9.35$, $p < 0.001$), such that the cataract simulation impaired driving performance to a greater extent for the older compared to the younger participants.

### 3.2. Component driving performance measures

When the data were considered as a function of the individual components of driving it was apparent that not all aspects of driving performance were affected in the same way by visual status and distracter tasks; the effects of age group also varied across different driving performance measures (Fig. 2A–D).

A significant main effect of vision condition was apparent for sign detection ($F_{2,74} = 140.7$, $p < 0.001$) and time to complete the course ($F_{2,74} = 164.21$, $p < 0.001$) but not for correct gap judgments ($F_{2,74} = 2.11$, $p = 0.129$) or total percentage of time outside of the lane ($F_{2,74} = 1.31$, $p = 0.28$). Post-hoc comparisons indicated that, where significant differences existed, they were between all visual

**Table 1**
Mean visual acuity and contrast sensitivity of each age group under the different visual conditions. Standard deviations shown in parentheses.

| Measure | Visual condition | Younger group mean (*SD*) | Older group mean (*SD*) |
|---|---|---|---|
| *Visual acuity* | | | |
| | Normal | −0.14 (0.02) | 0.00 (0.02) |
| | Blur | 0.14 (0.03) | 0.33 (0.03) |
| | Cataract | 0.18 (0.02) | 0.36 (0.02) |
| *Contrast sensitivity* | | | |
| | Normal | 1.88 (0.03) | 1.73 (0.03) |
| | Blur | 1.79 (0.03) | 1.61 (0.03) |
| | Cataract | 1.20 (0.06) | 1.06 (0.06) |

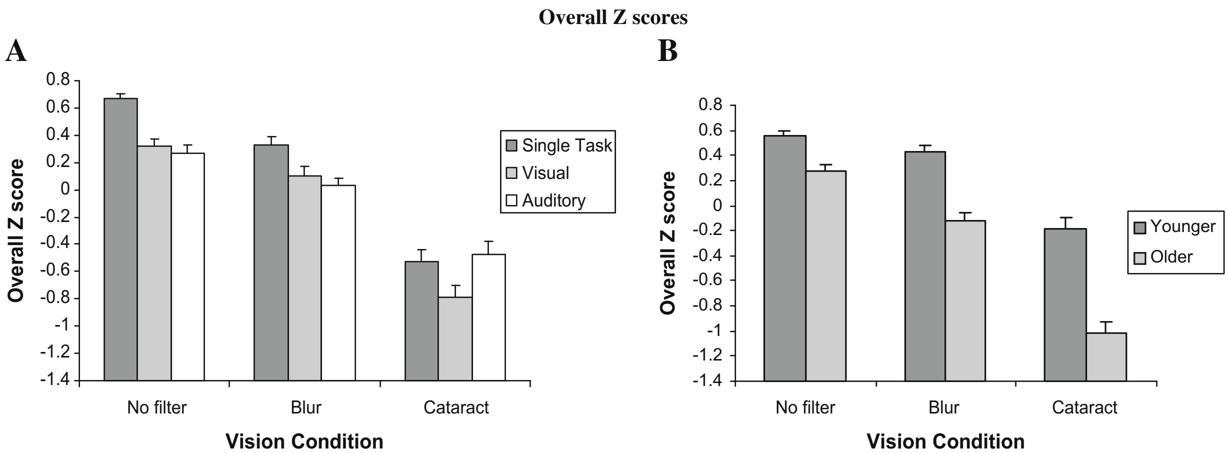


**Fig. 1.** (A) Group mean Z scores for all participants as a function of vision and distracter condition. (B) Group mean Z scores as a function of vision condition for the young and older participants.

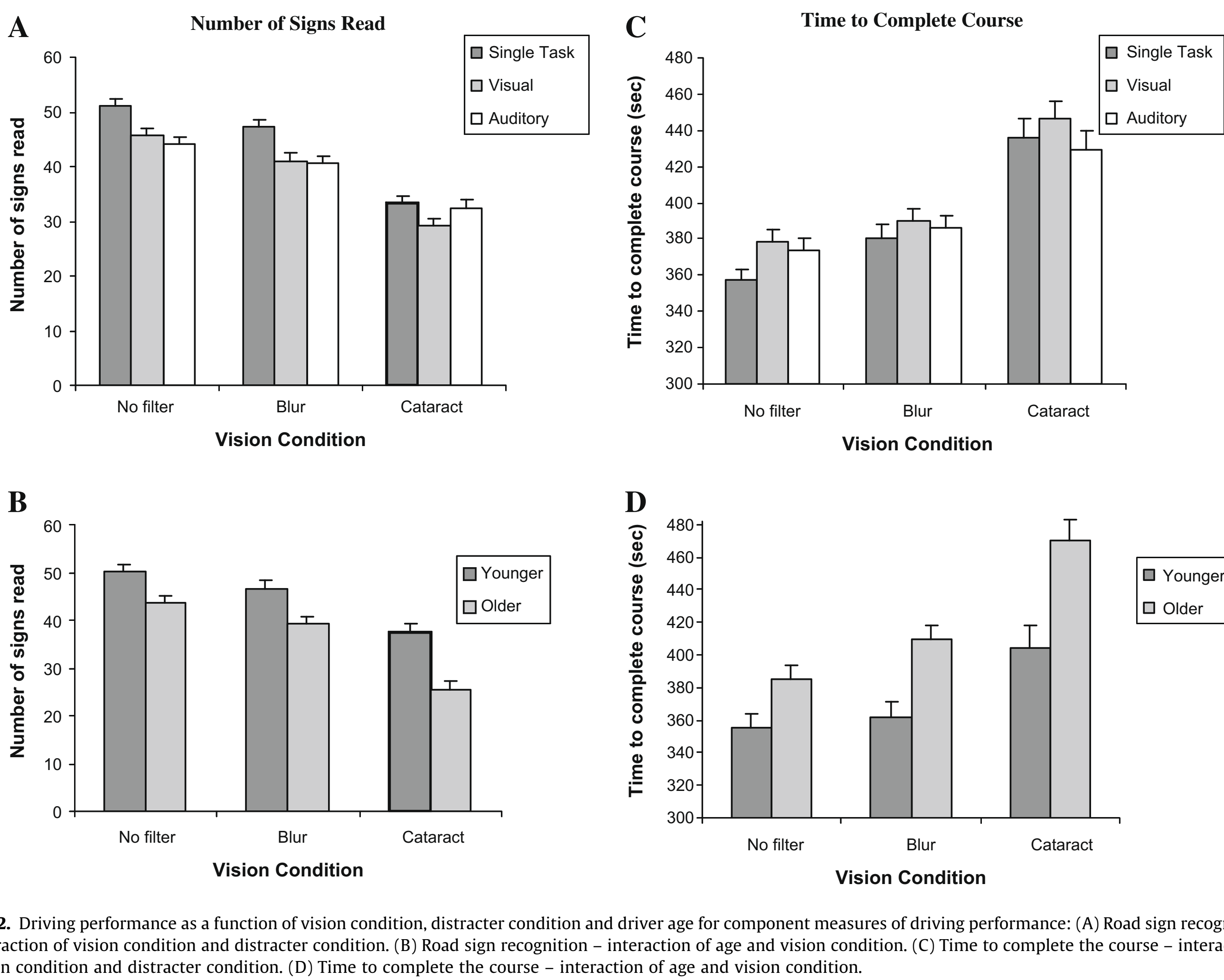


**Fig. 2.** Driving performance as a function of vision condition, distracter condition and driver age for component measures of driving performance: (A) Road sign recognition – interaction of vision condition and distracter condition. (B) Road sign recognition – interaction of age and vision condition. (C) Time to complete the course – interaction of vision condition and distracter condition. (D) Time to complete the course – interaction of age and vision condition.

conditions, where performance was worse for the cataract condition, followed by blur, with best performance for the normal visual condition.

There was a significant main effect of distracters for sign detection ($F_{2,74} = 29.39$, $p < 0.001$), time to complete the course ($F_{2,74} = 15.19$, $p < 0.001$), and correct gap judgments ($F_{2,74} = 8.72$, $p = 0.001$), but not for total percentage of time outside of the lane ($F_{2,74} = 0.56$, $p = 0.57$). Post-hoc comparisons demonstrated that under the distracter conditions participants saw fewer signs, made fewer correct gap judgments and took longer to complete the course than they did for the no distracter condition. Only time to complete the course was significantly different between the two distracter conditions, such that participants drove more slowly when driving under the visual distracter compared to the auditory distracter condition.

There was a significant interaction between vision condition and distracter for sign detection ($F_{4,148} = 4.58$, $p = 0.013$) and time to complete the course ($F_{4,148} = 4.25$, $p = 0.003$), but not correct gap judgments ($F_{4,148} = 0.882$, $p = 0.418$) or lane keeping ($F_{4,148} = 0.16$, $p = 0.957$). For signs read the interaction was the same as that observed in the overall performance scores. For time to complete the course, in the normal vision condition the single task condition resulted in shorter times than either of the distracter conditions, but the distracter conditions did not differ. For the blur condition, the three distracter conditions did not differ significantly. However, in the cataract condition, the auditory and single task conditions did not differ significantly, but the visual distracter produced significantly longer total times than the auditory distracter. Again, the worst performance overall was in the cataract condition, and particularly so in the presence of visual distracters.

There was a significant main effect of age, such that the younger drivers performed significantly better than did the older drivers for sign detection ($F_{1,37} = 18.4$, $p < 0.001$), and time to complete the course ($F_{1,37} = 12.28$, $p = 0.001$), but not correct gap judgments ($F_{1,37} = 1.81$, $p = 0.186$) or lane keeping ($F_{1,38} = 0.73$, $p = 0.40$).

Significant interaction effects were found between vision condition and age group for sign detection ($F_{2,74} = 4.58$, $p = 0.013$) and time to complete the course ($F_{2,74} = 6.41$, $p = 0.003$), but not correct gap judgments ($F_{2,74} = 0.88$, $p = 0.418$) or lane keeping ($F_{2,74} = 2.24$, $p = 0.11$). In both cases, the interactions demonstrate that the cataract simulation impaired driving performance to the greatest extent in the older subjects.

There were no significant two-way interactions between distracter and group, and no significant three-way interaction between distracter, vision and group.

### *3.3. Secondary task performance*

An analysis was also conducted of performance on the secondary task for each distracter and visual condition. There was a significant main effect of visual condition ($F_{2,74} = 29.96$, $p < 0.001$), such that overall there were significantly more sums missed in the blur and cataract conditions than in the normal vision condition, and more sums missed in the cataract than in the blur condition (Fig. 3). There was also a significant main effect of group, such that older participants missed significantly more sums than did the younger participants ($F_{1,37} = 8.39$, $p = 0.006$). There was a significant two-way interaction between distracter and age group ($F_{1,37} = 5.25$, $p = 0.028$), and also a three-way interaction between vision condition, distracter condition and age group ($F_{2,74} = 3.79$, $p = 0.027$). For the younger participants, in all visual conditions there were more sums missed in the auditory than visual presentation. For the older participants, similarly, there were more auditory sums missed than visual sums in the normal and blur conditions, but in the cataract condition, there were more visual than auditory sums missed.

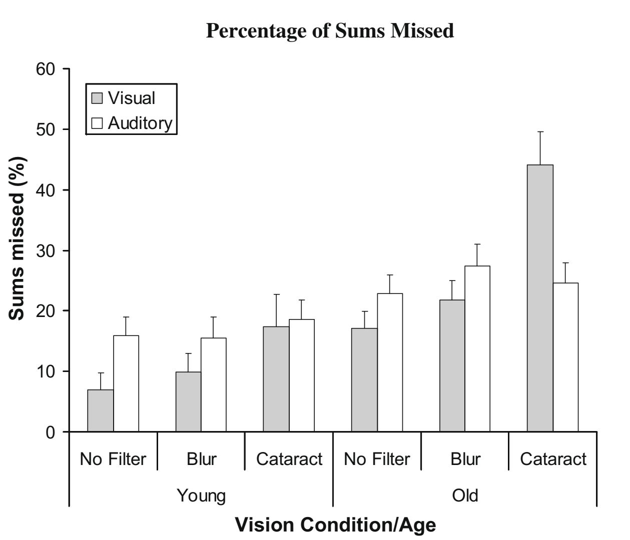


**Fig. 3.** Percentage of sums missed in each combination of vision and distracter condition as a function of age.

## 4. Discussion

The findings of this study demonstrate that the presence of simulated visual impairment and distracter tasks degraded driving performance and there was a significant interaction between the two. Older participants generally performed worse than the younger participants and there was a significant interaction between visual status and age, such that the simulated cataract condition resulted in a greater impairment in driving performance for the older compared to the younger participants.

Simulated visual impairment significantly reduced overall driving scores, reducing the number of road signs participants were able to read and slowing their performance on the course, as indicated by a longer mean time to complete the circuit. These findings are supported by previous studies that have shown that both simulated and true cataracts have a detrimental effect on a range of indices of driving performance (Owsley et al., 1999, 2001; Wood & Carberry, 2006) and refractive blur significantly impaired all aspects of driving performance in agreement with previous closed road studies (Higgins & Wood, 2005; Higgins, Wood, & Tait, 1998). Importantly, the simulated cataracts resulted in the greatest decrement to driving performance, despite the fact that the visual acuity for the cataract and blur conditions was matched as closely as possible (within a 0.25 dioptre step) for each participant individually. Thus the changes in driving performance are likely to result from the decrease in contrast sensitivity (and to some extent increase in glare) induced by the cataract goggles and not differences in visual acuity. This concurs with other studies which have highlighted that changes in contrast sensitivity rather than changes in resolution, are responsible for impairments in other functional outcome measures such as postural stability (Anand et al., 2003), and face recognition and mobility under low luminance conditions (Elliott, Bullimore, Patla, & Whitaker, 1996). Alternatively, it may be that participants are better able to adapt to blur than to simulated contrast sensitivity loss, given that optical blur is more commonly encountered in everyday activities when individuals fail to wear an appropriate spectacle correction, whereas loss of contrast sensitivity is encountered less commonly. The issue of adaptation is also important given that uncorrected refractive error is the main cause of visual impairment in older populations (VanNewkirk, Weih, McCarty, & Taylor, 2001) and underscores the importance of further research in this area.

Interestingly, gap judgment and lane keeping ability were not affected by visual status. The lack of effect of visual impairment on the gap judgment task is in support of our previous studies (Higgins & Wood, 2005; Higgins et al., 1998), and may potentially be explained by the high contrast nature of the cones used for this task, which may provide adequate visual cues to gap size even in the presence of visual impairment. Alternatively, the cues required for gap judgment may not be affected by the level of blur and cataracts included in this study. The findings for lane-keeping are in support of driving simulator studies which have shown that lane keeping ability is robust to even extreme amounts of blur of up to 8–10 dioptres (Brooks, Tyrrell, & Frank, 2005; Owens & Tyrrell, 1999). Indeed, the findings of our study are consistent with the so-called "selective degradation" theory which suggests that increased optical blur (and decreased luminance) produce reductions in acuity-mediated recognition vision, while leaving peripheral field guidance vision relatively unaffected (Leibowitz, Rodemer, & Dichgans, 1979). Thus, while blur and simulated cataracts resulted in significant decrements in sign recognition, other tasks such as steering through cones and maintaining lane position were relatively unaffected, presumably because they can be performed using ambient (peripheral field) visual functions.

The findings also demonstrate that overall, driving performance was worse in the presence of a distracter task in accord with previous driving simulator studies (Strayer & Johnston, 2001). The distracter tasks appear to cause interference affecting detection of signs and changes in the driving scene which is in support of previous studies (Recarte & Nunes, 2003). The visual and auditory distracter tasks had similar effects on all measures of driving performance, with the exception of time to complete the course, wherein the visual distracter task increased driving time to a greater extent than did the auditory. Engström, Johansson, and Östlund (2005) also showed that visual distracters had more effect on driving speed than did auditory distracters, but they also found that lane keeping was impaired by visual but not auditory distracters, whereas our results failed to reveal any effect of distracters on lane keeping.

The worst performance overall was found with the combination of simulated cataracts, and visual distracters, which is highly relevant to the problems of increased visual impairment in older drivers. One side effect of cataracts is that they may increase the attentional demands of driving. The ability to perform concurrent tasks may be compromised because the processing and interpretation of visual input may represent a significant attention demanding task in itself (Turano et al., 1998). The reduced stimulus contrast caused by cataracts can slow or impair the recognition and processing of visual environmental cues (Harley, Dillon, & Loftus, 2004; Pashler, 1984), resulting in a strategic slowing of driving speed, potentially exacerbating the effects of age-related cognitive slowing (Salthouse, 1996).

Cataracts might also compromise older drivers' effectiveness in multitasking. This is evidenced by the finding that the number of sums missed was highest in the cataract condition for both the visual and auditory presentations, where older participants missed almost half of the distracter presentations when driving with simulated cataracts in the presence of visual distracters. Indeed, older participants commented that they often felt uncomfortable when taking their eyes off the road to look at the visual display, especially under the cataract condition. They appear to have responded by emphasizing vehicle control over the other tasks, particularly as the secondary visual task required them to take their eyes off the road. The finding that the secondary task performance of the older participants varied both with the mode of presentation and the visual status of the drivers, while that of the younger drivers was always worse for auditory presentation is novel. Task coordination is potentially more difficult when a summing problem is presented in the auditory modality, because attending to the problem requires listening to the auditory stream, requiring ongoing attention, and also occupies phonological working memory while the problem is deliberated. This is likely to be more engaging than the visual task, wherein the driver can scan the display more quickly, and at their own pace. The visual dual task provides some level of flexibility because the sums were continuously available on the dashboard-mounted display (for an average of 3.5 s) until the next number pair was presented. The participants could potentially coordinate the multiple task demands, attend to the visual sums task, and report the result when it was convenient. We would anticipate that the effect of visual distracters on driving performance would have been even greater had the participants attempted all of the sums.

Overall, the driving performance of the older drivers was significantly worse than that of the younger participants, which concurs with previous reports of higher crash rates for older drivers compared to their younger counterparts (McGwin & Brown, 1999). The lack of interaction between driver age and distracter type is in accord with recent studies on driving simulators, which have shown that the impact of secondary tasks on driving performance is not significantly affected by driver age (Strayer & Drews, 2004). The interaction between driver age and visual condition arises because the driving performance of the older participants was affected to a greater extent by the simulated cataract condition than was the younger participants. This could be a result of the reduction in attentional capacity for older compared to younger individuals (Strayer & Drews, 2004). It is also possible that the younger participants were able to adapt more easily to the simulated visual impairment than the older participants. Importantly, the effects of the simulating goggles on clinical measures of visual acuity or contrast sensitivity did not differ according to age, indicating that under laboratory-based conditions at least, the cataract goggles did not impair these measures of visual function to a greater extent for the older compared to the younger participants. However, it is not known whether this would have been the case had these measures of visual function been recorded under the open road conditions of the driving track where the effects of glare and light scatter are clearly evident; this underscores the limitations that many clinical tests have in reflecting real-world performance.

In summary, the results suggest that the performance of both young and older drivers was affected by the presence of simulated visual impairment and also by the presence of a distracter task, such that simulated cataracts caused the greatest decrement in performance under the visual distracter condition, and simulated cataracts reduced performance more for older drivers. Importantly, while the level of visual acuity for the blur and cataract conditions was matched, the impact of impairment from the cataract condition on driving performance far exceeded that of blur, indicating that contrast sensitivity may be a more important mediator of the detrimental effects of cataracts on driving performance.

While the use of simulated visual impairments allowed us to partial out the effects of vision alone, without introducing variations in experience or personality type, it is recognised that the effects observed in this study may be greater than for people with true vision impairment. These individuals potentially have the opportunity to visually adapt to their impairment and over time may learn compensatory strategies that mitigate some of the effects observed here. Previous data from our laboratory, however, indicates that even among those with true cataracts the same kinds of driving deficits are observed (Wood & Carberry, 2006). Studies are currently being undertaken to address this question by investigating the impact of multi-tasking for older drivers with a range of true visual impairments. The findings from this study provide a basis for future investigations that further determine the interactions between the visual perception, attention and cognitive load in visually guided behaviours. Such research will also lead to a better understanding of the effects of commonly occurring visual impairments, such as cataracts, on driving behaviour and the acquisition of driving-related information.

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