THE EFFECTS OF IN-VEHICLE AUDIOVISUAL DISPLAY UNITS ON SIMULATED DRIVING

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Executive summary

Aims

This research program aims to evaluate whether:

- drivers are likely to attend to the visual materials from an in-vehicle audiovisual unit that is visible from the back of another vehicle [survey];
- the visual materials from an in-vehicle audiovisual display unit positioned as in the back of an adjacent vehicle impairs driving performance [Experiment 2];
- the audio materials from an in-vehicle audiovisual display unit impairs driving performance [Experiment 1].

Background

According to Rule 299 of the Australian Road Rules:

"A driver must not drive a motor vehicle that has a television or visual display unit in or on the vehicle operating while the vehicle is moving, or is stationary but not parked, if any part of the image on the screen:
(a) Is visible to the driver from the normal driving position; or
(b) Is likely to distract another driver."

Audiovisual display units that are positioned so that they are only visible to occupants seated in the rear of the vehicle are currently deemed acceptable because they accord with Clause (a), and because there is no direct evidence to indicate that they contravene Clause (b).

Nonetheless, it is possible that a driver who is distracted by seeing an audiovisual display unit within the vehicle [as implied by Clause (a)] will also be distracted by an audiovisual display seen in another vehicle.

Thus, with respect to Clause (b), the present research examined whether drivers are likely to attend to audiovisual display units in other vehicles [survey], and be distracted so that their driving is impaired [Experiment 1].

Rule 299 appears to be primarily concerned with preventing visual distraction of drivers. However, cognitive distraction by a secondary task (such as conversation) also appears to play a critical role in the driving impairments produced by a number of sources including mobile phones, navigational systems, and passengers.

The audio materials from an audiovisual program are likely to be cognitively distracting. Like a phone conversation, these audio materials must be attended to for their content to be understood. Audio material from an audiovisual program may be more cognitively distracting than radio, which is designed to be understood in the absence of visual information.

Thus, the present research aimed to examine whether audio material from an audiovisual program (and from radio) impairs driving.

Methods

For each experiment, approximately 30 Participants were recruited from the general population (using newspaper advertisements and posters) to achieve an approximately representative spread of age and gender.

For Experiment 1, an audiovisual display unit was positioned outside the driving simulator car body as though it were in the back of a car in a neighbouring lane. Each participant completed 3 drives with visual material being presented (each without sound), and one drive without audiovisual material. If they are not given instructions (as indeed they are not given instructions on the road) participants are likely to try to guess the experimenter's aims, and some participants may assume that they should ignore the materials, whereas others may assume that they should attend to the materials (regardless of what they would do in real-world driving). Thus, in order to ensure a complete picture instructions were manipulated as follows:

1. Visual materials presented; instructed to ignore (arguably most representative of what is *implicitly* required on the road);
2. Visual materials presented; instructed to attend (the purest measure of driving performance *when the driver is attending to the visual materials from an audiovisual program),* followed by a short quiz to assess attention;
3. Visual materials presented; no instruction (arguably most representative of the on road situation, where drivers are not given explicit instructions);
4. Control (no visual materials presented).

To minimise order, practice and fatigue effects, the order of conditions was counterbalanced, crossed with the counterbalance orders of 2 different drives (refined from drives that have previously been employed successfully to detect distraction effects), and of 3 different film excerpts (from a children's film that was chosen to be unfamiliar, so that attention was required to follow the story).

For Experiment 2, each participant completed drives under each of the following 3 conditions:

1. Audio materials (from a children's film that was chosen to be unfamiliar, so that attention was required to follow the story) presented via speakers that were positioned on the back of the front seats of the vehicle facing the rear;
2. Audio materials from a radio talk-back show presented from speakers positioned in the front of the vehicle facing the rear;
3. Control (no audio materials presented).

The order of conditions was fully counterbalanced, and crossed with the counterbalance orders of the two different drives.

Participants of both experiments completed a questionnaire that was purpose-designed to examine their experiences in the simulator (perceived distraction and performance impairment), on-road experiences of audiovisual units (e.g. whether participants have seen them, and attended to them, whilst driving), and personal characteristics (e.g. hours driving per week, age, gender). Another questionnaire examined participants' motivation and availability to take part in the study. Participants were offered two movie tickets as compensation for their time, effort, and travel expenses.

Statistical analysis

To address the aims of the study, all continuous simulator-related dependent variables (e.g. speed, speed approaching hazards, lateral position, standard deviation of lateral position, number of speed exceedances, self-reported distraction) were analysed employing planned repeated measures ANOVAs. Practice drive performance measures were treated as potential covariates, and included in the above analyses if found to be significantly related to the dependent variable. Dichotomous dependent variables (e.g. ran red lights) were analysed employing Chi-squares.

Results, conclusions, and recommendations

The findings of the present study suggest that audiovisual display units that are visible from another vehicle are likely to distract drivers and impair their driving performance.

- Of the 26.2% of the sample that reported that they had seen an audiovisual display unit in another vehicle, 80% reported that they had paid at least "a little" attention to the last unit they had seen while driving.

- In the simulator, drivers instructed to attend to audiovisual materials
    1. had a lower mean speed over the entire drive, and approaching traffic lights or pedestrians;
    2. decelerated more slowly when confronted by a pedestrian;
    3. kept a mean lane position on a curvy section of road that was further to the left of centre;
    4. had lower mean road heading error;
    5. had lower variability in acceleration; and
    6. kept a more variable lane position on a curvy section of road;

  compared to the control condition.

- All of these effects of attending to the visual materials of an audiovisual display unit in another vehicle (except 4 and 5) are likely to reflect impairment.

- No differences from the control condition were observed when drivers were instructed to ignore the materials.

- When drivers received no instruction (when most of them assumed that they should ignore the materials), performance differed from the control condition only with practice drive performance statistically controlled.

- Our results may underestimate the impairment produced by attending to the smaller audiovisual display units that are currently available in vehicles. Participants' self-reports indicate that they *do* attend to the smaller screens that are currently available, and smaller screens may produce greater impairment because of the greater cognitive capacity required to make out the materials being screened.

- 96.4% of the sample reported that they were at least "a little" distracted by the visual materials from an audiovisual display unit whilst they were driving in the simulator, and 96.4% of the sample reported that their driving was at least "a little" impaired. 17.9% of participants reported that their driving was at least "much" impaired.

Navigational systems in other vehicles may also be problematic. Of the 21.3% of the sample that reported that they had seen an audiovisual display unit in another vehicle, 75% reported that they had paid at least "a little" attention to the last unit they had seen while they were driving. Impairments are likely to be similar to those observed for an audiovisual display.

The findings of the present study suggest a limited effect of the audio materials of an audiovisual program playing in the back of a vehicle, or of radio, on simulated driving performance (despite self-reports).

These research conclusions would be unlikely to change given a larger sample.

The relevant authorities should consider amending the Australian Road Rules to require that audiovisual displays not be visible to other drivers. This may be achieved through appropriate screen design.

Aims

The purpose of this project was to evaluate the effects of in-vehicle audiovisual display units on driving, using a driving simulator. This purpose was served by three distinct aims:

1. To examine whether drivers are likely to attend to the visual materials of an audiovisual program from an audiovisual display unit that is visible from the back of another vehicle;
2. To examine whether attending to the visual materials of an audiovisual program from a unit positioned as a front seat-back display in another vehicle impairs driving performance, relative to control conditions (various instructions, or no audiovisual display);
3. To examine whether the audio materials of an audiovisual program from a unit positioned in the back of the vehicle (so that the driver cannot see it) impairs driving performance, relative to a control condition (no audio materials), and relative to radio sounds.

Background

Rule 299 of the Australian Road Rules states in part:

"A driver must not drive a motor vehicle that has a television or visual display unit in or on the vehicle operating while the vehicle is moving, or is stationary but not parked, if any part of the image on the screen:

(a) Is visible to the driver from the normal driving position; or
(b) Is likely to distract another driver."

Audiovisual display units that are positioned so that they are only visible to occupants seated in the rear of the vehicle (e.g. suspended from the ceiling in the middle of the vehicle, or positioned on front seat-backs) are currently deemed acceptable because they accord with Clause (a), and because there is no direct evidence to indicate that they contravene Clause (b).

However, it would seem indefensible to argue that an audiovisual display unit that can be seen from another vehicle would not be distracting, when- as is implied by Clause (a)- a unit that can be seen within the vehicle *is* distracting[1]. Of course, an audiovisual display unit in another vehicle would typically be seen without sound, and from a greater and (because of differing velocities) more variable distance. Whilst these differences may result in an audiovisual display unit in another vehicle being less likely to attract attention, they may also result in more attention being required to understand the audiovisual materials. Further, an audiovisual display unit in another vehicle may be more of a novelty, and so more likely to attract attention.

To date, there is no research examining the likelihood that drivers will watch the visual materials of an audiovisual unit positioned where it can be seen in another vehicle. Research on in-vehicle navigation systems is also not clear on this point, because it has *required* participants to watch a display *within* the vehicle they were driving. If anything, drivers are more likely to spontaneously watch an in-vehicle audiovisual (rather than a navigational system) display unit that is visible from another vehicle, because of its more interesting content.

The present research included a survey assessing whether drivers are likely to attend to the visual materials from an audiovisual, or navigation system, display unit that is visible from another vehicle.

Further, there is as yet no *direct* evidence regarding the likelihood that watching the visual-materials in another vehicle would impair driving.

Rule 299 appears to reflect an assumption that *visual* distraction of drivers is the primary threat to driving performance posed by in-vehicle display units. Indeed, it seems obvious that removal of visual attention from the road is likely

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[1] It also seems peculiar to suggest- as the rule appears to- that an in-vehicle audiovisual display that is distracting to other drivers when the vehicle is stationary would not also be distracting when the vehicle is stopped.

to impair driving, and research regarding the effects of in-vehicle navigations systems supports this claim.

In an on-road study, in-vehicle navigational systems with voice guidance (which require little visual attention) were associated with fewer braking errors and lane deviations compared to purely visually-based navigation systems (Dingus, McGehee, Hulse, Jahns, & Manakkal, 1995). Similarly, Srinivasan and Jovanis (1997) found in-vehicle navigations systems with voice guidance were associated with faster mean speeds than a conventional paper map (requiring visual attention). They concluded that the lower speeds associated with map-reading reflected compensation and awareness of increased risk.

Cognitive demands of using a navigational system may also impair driving. Biever (2000) examined the influence of complexity in the task of using an in-vehicle information system (combinations of: listening, planning, and computing) on driving performance. Drivers were less able to maintain their lateral position as task complexity increased.

That cognitive distraction may also contribute to driving impairments has been recognised in literature regarding the effects of mobile phone use on driving (see Brown, Tickner, & Simmonds, 1969). For example, Lamble, Kauranen, Laakso & Summala, 1999) attributed the deficits they observed in driving performance to physical, visual, *and* non-visual (e.g. memory, concentration) impairments.

Research has not often attempted to discriminate between impairments resulting from holding a phone, looking at a phone, and attending to a conversation. However, the importance of cognitive impairments is suggested by some studies showing that the impairments produced by using hand-held phones are comparable to those produced by using hands-free phones (Haigney, Taylor, and Westerman, 2000), or even by communicating with a passenger. For example, communicating whilst driving in a driving simulator has been found to result in increased reaction time to braking response (Consiglio, Driscoll, Witte, & Berg, 2003) and decreased lane-keeping performance (Haque, Hatfield, and Job (2002), regardless of whether the communication was via a hand-held or hands-free mobile phone or with a passenger. Haque et al. (2002) also found that drivers who were communicating drove faster than those who were not, with faster driving observed for communication on a hands-free mobile phone than on a hand-held mobile phone (suggesting that people on a hand-held phone compensate more for the interference). Strayer and Johnston (2001) found that unconstrained conversations resulted in a two-fold increase in the failure to detect simulated traffic signals and a slower reaction to those signals detected, regardless of whether a hand held or hands free mobile phone was used. Finally, the importance of cognitive impairments is suggested by Nunes & Recarte’s (2002) finding that whilst high-demand phone conversations significantly affected the visual processing capacities of drivers, low-demand phone conversations produced null or low effects.

Thus, if watching the visual materials from an audiovisual display unit in another vehicle involves some cognitive demand (as it is likely to), then this is likely to contribute to impaired driver performance.

The present research examined whether attending to the visual materials of an audiovisual program from a unit positioned as a front seat-back display in another vehicle impairs driving performance.

Given these findings, hearing (whilst not seeing) the audio materials from an audiovisual program is likely to be cognitively distracting. Like a phone conversation, these audio materials must be attended to for their content to be understood. Indeed the “story” of an audiovisual program is likely to be more complex than the average phone conversation, and so more distracting.

Audio material from an audiovisual program is also likely to be more cognitively distracting than radio, which is designed to be understood in the absence of visual information; however this possibility is yet to be examined.

Thus, it is pertinent to examine whether the audio materials of an audiovisual program from a unit positioned in the back of the vehicle (so that the driver cannot see it), or the radio, impairs driving performance.

Design

In order to examine whether drivers are likely to attend to the visual materials of an audiovisual program from a unit that is visible from the rear of a vehicle, a brief survey (of participants in both Experiment 1 and Experiment 2) investigated whether participants have ever seen an audiovisual display in another vehicle, where it was positioned, and whether they attended to it (when driving or passenger).

In addition, two experiments were conducted: Experiment 1 to assess the effect of vision without sound (as for a driver viewing an audiovisual screen positioned in the back of another car); and Experiment 2 to assess the effect of sound without vision (as for a driver with an audiovisual system positioned in the back of the car they are driving). Both studies were within-subjects designs (in which each participant performs each condition). This within-subjects design was employed to minimize unnecessary variance due to individual differences (thereby increasing the likelihood of detecting real effects), and to minimize the number of participants required (thereby increasing time efficiency).

Experiment 1

An audiovisual display unit (laptop PC) was positioned outside the driving simulator car body as though it were in the back of a car in a neighbouring lane (given the context of the simulator environment) [see Figure 2].

Participants completed 3 drives with the visual (but not the audio) material from the audiovisual program being presented, and one drive without audiovisual material. If they are not given instructions (as indeed they are not given instructions on the road) participants are likely to try to guess the experimenter’s aims, and some participants may assume that they should ignore the audiovisual display (when they may not in real-world driving), whereas others may assume that they should attend to the display (when they may not in real-world driving). Thus, in order to obtain a complete picture participants were exposed to three audiovisual conditions (plus a control condition):

1. Visual materials presented; instructed to ignore
2. Visual materials presented; instructed to attend
3. Visual materials presented; no instruction
4. Control (no visual materials presented)

The instruction to ignore is arguably most representative of what is *implicitly* required on the road. The instruction to attend gives the purest measure of driving performance *when the driver is attending to the visual materials from an audiovisual program.* No instruction is arguably most representative of the on road situation (where drivers are not given explicit instructions), although participants’ are likely to assume an instruction in an experimental situation.

The four orders of condition counterbalance are presented in the first 4 rows of Table 1. The selection of these orders ensures that all subjects experience condition 3 (“no instruction”) as their first audiovisual condition (to leave this condition unbiased by any previous instruction about attention), and that there are an equivalent number of orders in which the control condition is the first versus the last drive (to control for practice and fatigue effects). Other possible orders do not meet these conditions.

The drives primarily assess distraction, by assessing driver response to potentially hazardous situations (e.g. pedestrians stepping onto the road). Because an element of surprise is relevant to such responses, there were two versions of the drive: Drive A and Drive B [see Tables 3 and 4]. For each condition order, every participant who does the drives in order ABAB is matched by a participant who does the drives in order BABA [see Table 1, rows 1-4 vs 5-8].

So that the audiovisual materials had a similar capacity to distract in each condition, a novel movie excerpt was presented in each of conditions 1-3 for any given participant, and counterbalanced as depicted in Table 1.

Table 1: Counterbalance orders involved in Experiment 1

Counterbalance order	Condition order	Drive order	Film order
1	3124	ABAB	123
2	3214	ABAB	123
3	4312	ABAB	123
4	4321	ABAB	123
5	3124	BABA	123
6	3214	BABA	123
7	4312	BABA	123
8	4321	BABA	123
9	3124	ABAB	321
10	3214	ABAB	321
11	4312	ABAB	321
12	4321	ABAB	321
13	3124	BABA	321
14	3214	BABA	321
15	4312	BABA	321
16	4321	BABA	321
17	3214	ABAB	213
18	3124	BABA	213
19	4312	ABAB	213
20	4321	BABA	213
21	3124	ABAB	231
22	3214	BABA	231
23	4312	ABAB	231
24	4321	BABA	231

Experiment 2

A laptop PC was positioned in the boot the driving simulator car body, and connected to speakers in the front of the vehicle, and in the rear of the vehicle (on front seatbacks), all facing the rear of the vehicle.

Each subject completed a drive under each of 3 conditions:

1. Audio materials from audiovisual program presented (via seatback speakers)
2. Audio materials from radio presented (via speakers in the front of the vehicle)
3. Control (no audio materials presented)

The order of conditions was completely counterbalanced across subjects to avoid order, practice and fatigue effects [see Table 2]. Again, there are two versions of drive [see Tables 3 and 4]. For each condition order, every participant who did the drives in order ABA was matched by a participant who did the drives in order BAB [see Table 2].

Table 2: Counterbalance orders involved in Experiment 2

Counterbalance order	Condition order	Driver order
1	123	ABA
2	132	ABA
3	213	ABA
4	231	ABA
5	312	ABA
6	321	ABA
7	123	BAB
8	132	BAB
9	213	BAB
10	231	BAB
11	312	BAB
12	321	BAB

Methods

Participants

A total of 59 participants were recruited (28 in Experiment 1, and 31 in Experiment 2). Recruitment involved posting advertisements on and around the University of NSW (UNSW), Kensington campus, as well as placing an advertisement in the Southern Courier. The Southern Courier covers a number of Sydney's inner southwestern suburbs; including, Alexandria, Centennial Park, Kingsford, Mascot, Randwick, Pagewood, Maroubra, Botany, and La Perouse. Whilst there is likely to be a sample selection bias involved in advertising only in the area local to UNSW, this bias would have been imposed in any case by the need to travel to UNSW to participate. The advertisement called for licensed drivers to participate in a study "examining the influence of in-car audiovisual displays on simulated driving".

The advertisement informed the reader that participation would require them to come to UNSW to complete drives on a simulator and a questionnaire in an hour-long session. The advertisement stated that participants would receive 2 movie tickets to compensate for time and travel expenses [see Appendix A].

Items were included in the questionnaire to assess participants' reasons for volunteering, and for their availability during business hours, so that any likely selection biases could be considered.

For Experiment 1, one participant was unable to complete the driving session due to simulator sickness, and the data for another participant failed to record correctly (Total sample = 28). Two participants in Experiment 2 were unable to complete the driving session due to simulator sickness and data for a further two participants failed to record correctly. For Experiment 2, one participant was replaced (Total sample=27).

The sample for Experiment 1 was 50.0 % female, with an average age of 42.1 years (range: 20 – 69 years). The sample for Experiment 2 was 42.9% female, with an average age of 38.9 years (range: 22 – 68 years).

Materials

STISIM Driving Simulator

The driving simulator, situated in a room in the School of Psychology, UNSW, provides an interactive driving experience, with immediate visual and auditory feedback. It consists of the cab of a Hyundai Excel with automatic transmission, including a modular steering unit with 360 degree, speed sensitive steering capability, accelerator and brake pedal unit. Vehicle speed is displayed on the speedometer in the instrument panel. The simulated visual scene is projected from three projectors onto three screens (each 1.42m x 1.14m in size), giving the driver a 135-degree field of view.

The simulation (driving scenario) is programmed on software developed by Systems Technology Inc (STI) and runs on a multiprocessor computer with three 133 MHz Pentium processors. The programs describe the position, orientation, and speed of road segments, on-road objects (e.g. cars, traffic signals, pedestrian barriers), and roadside objects (e.g. speed limit signs, pedestrians, trees, buildings). A high-speed graphics accelerator, providing a visual update of 20 Hz, with texturing, shading and lighting, produces reasonable scene resolution. The simulator also provides immediate auditory feedback including tire screeching, and collision sounds.

Figure 1 shows the car body in relation to the screens, and an example of the simulated graphics. Figure 2 shows the location of the laptop PC used to present visual materials in Experiment 1.

Figure 1: Simulator car body, screens, and example graphics

Figure 2: Simulator car body, screens, and laptop PC presenting visual materials

The STISIM software also allows recording of a wide range of driver performance variables.

Simulator drives

A practice drive lasting for approximately 5 minutes gave subjects practice at accelerating, braking, and handling pedestrians crossing the road.

The test drives employed were slightly refined versions of drives that have been designed, and found, to assess distraction effects (resulting from mobile phone use; Haque et al., 2002).

The drives employed in Experiment 1 are detailed in Table 3 (Drive A) and Table 4 (Drive B). Drive B differed from Drive A in that in Drive B the pedestrian emerges from a different location, the first curve is to the right (rather than left) and vehicles enter from the left (rather than right), and the second curve is to the right and vehicles enter from the right.
For both drives, the following variables were recorded every 10 metres for the duration of the drive: speed, lateral position[2], curvature error, road heading error, and speed exceedances [see Table 8]. Thus, mean values could be computed across the entire drive. Some of these data were employed to compute variables relating to specific segments of the drive. For example,

[2] Lateral position is measured in relation to the roadway dividing line (between opposing directions of traffic) and the centre of the car body (in longitudinal distance). Because the lane is 4m wide, the optimal position is therefore -2m.

mean speed approaching specific hazards (i.e. each traffic light, each cross-traffic intersection, and the pedestrian event) was computed for the sections immediately prior to the hazards. Tables 3 and 4 specify the data extracted for this purpose. Lateral position was computed for the final section of the drive (1.5km), which involved primarily curves.

For the entire drive, the program recorded standard deviation for acceleration, throttle input, lateral position, curvature error, road heading error, steering wheel input, and road heading error. Standard deviation in lateral position was also recorded separately for the final section of the drive.

Red lights ran and collisions with traffic at an intersection were recorded so that they could be examined as single instances or as a proportion of all the traffic lights or intersection events that occurred over the duration of the drive.

Table 3: The main sequence and locations of events, obtained data, and differences between experiments 1 and 2 for Drive A.

Distance travelled from start (metres)		**Description of event**		**Obtained data**	
Experiment 1	**Experiment 2 (deviations from Experiment 1)**	**Experiment 1**	**Experiment 2 (deviations from Experiment 1)**	**Experiment 1**	**Experiment 2 (deviations from Experiment 1)**
700	90 metres later (790m)	Roadway sign indicating upcoming traffic lights at an intersection.	Same		
900	15 metres later (915m)	Driver approaches traffic lights at intersection that remain amber for 3 seconds then turn red.	Same	300 metres prior	170 metres prior
1300	230 metres later (1530m)	Pedestrian appears from behind a car 4m to the right of the roadway's dividing line (the dashed line between traffic). Pedestrian crosses road at 1.5 km/hr when driver is within 5 sec of a collision. An oncoming vehicle reaches the pedestrian in the other lane simultaneously.	Pedestrian appears from behind a car 6m to the left of the roadway's dividing line (the dashed line between traffic) and proceeds to cross the road at 3.30 km/hr when the driver is within 10sec of a collision.	10 sec prior to point of collision	1 sec prior to point of collision
1780		Roadway sign indicating upcoming traffic lights at an intersection.	No road sign indicating upcoming traffic lights		
Second light event occurs after pedestrian (1980)	Second light event occurs before pedestrian (1220m)	Driver approaches traffic lights at intersection remain amber for 9 seconds then turn red.	Same	300 metres prior	Data not obtained
2070		Vehicle approaches from behind then overtakes.	No vehicle approaches from behind		
3970	2240	Roadway sign indicating left curve in the road.	Roadway sign indicating right curve in road		
4020		Roadway sign indicating upcoming intersection.	No roadway sign indicating upcoming intersection.		
4220	2640	Full intersection with give way sign and vehicles crossing from the right following the curved road.	Same	300 metres prior	250 metres prior
4500	3535	Roadway sign indicating upcoming traffic lights at an intersection.	Roadway sign indicating upcoming traffic lights at an intersection.		
4700	3660	Driver approaches traffic lights at intersection that remain amber for 3 seconds then turn red.	Driver approaches traffic lights at intersection that remain amber for 3 seconds then turn red.	300 metres prior	170 metres prior
5150	5230	Roadway sign indicating left curve in the road.	Vertical curve in road.		
5200		Roadway sign indicating upcoming intersection.	No roadway sign indicating upcoming intersection.		
5400	5530	Full intersection with give way sign and vehicles crossing from the left following curved road.	Full intersection with give way sign and vehicles crossing from the right following curved road.	300 metres prior	150 metres prior
6500	6250	End of Drive A	End of Drive A		

Table 4: The main sequence and locations of events, obtained data, and differences between experiments 1 and 2 for Drive B.

Distance travelled from start (metres)		Description of event		Obtained data	
Experiment 1	**Experiment 2 (deviations from Experiment 1)**	**Experiment 1**	**Experiment 2 (deviations from Experiment 1)**	**Experiment 1**	**Experiment 2 (deviations from Experiment 1)**
700	90 metres later (790m)	Roadway sign indicating upcoming traffic lights at an intersection.	Same		
900	15 metres later (915m)	Driver approaches traffic lights at intersection that remain amber for 3 seconds then turn red.	Same	300 metres prior	170 metres prior
1300	P1 = 1341 P2 = 1342 P3 = 1342 P4 = 1343 P5 = 1344 P6 = 1344	Pedestrian appears from a house 4m from the outer edge of the left hand side of the road. Pedestrian proceeds to cross at 1.5km/hr when the driver is within 5sec of a collision. An oncoming vehicle reaches the pedestrian simultaneously in the adjacent lane.	Six pedestrians appear from a house 8.23m left of the roadway's dividing line (the dashed line between traffic). The pedestrians proceed to cross the road at 5.49km/hr when the driver is within 4.5, 4.0, 3.5, 3, 2.5, and 2sec of a collision with pedestrians 1 to 6, respectively.	10 sec prior to point of collision	1 sec prior to point of collision
1460		Roadway sign indicating upcoming traffic lights at an intersection.	No road sign indicating upcoming traffic lights.		
1660	Second light event occurs before pedestrian (1220m)	Driver approaches traffic lights at intersection that remain amber for 9 seconds then turn red.	Same	300 metres prior	Data not obtained
1750		Vehicle approaches from behind then overtakes.	No vehicle approaches from behind.		
3650		Roadway sign indicating right curve in the road followed by right curve.	No roadway sign indicating left curve in the road. Left curve in road		
3700		Roadway sign indicating upcoming intersection.	No roadway sign indicating upcoming intersection		
3900	3400	Full intersection with give way sign and vehicles crossing from the left following the curved road.	Full intersection with give way sign and vehicles crossing from the right following the curved road.	300 metres prior	152 metres prior
4300	4450	Roadway sign indicating upcoming traffic lights at an intersection.	Same		
4500	4572	Driver approaches traffic lights at intersection that remain amber for 3 seconds then turn red.		300 metres prior	122 metres prior
5150	5486	Roadway sign indicating right curve in the road.	Roadway sign indicating right curve in the road		
5200		Roadway sign indicating upcoming intersection.	No roadway sigh indicating upcoming intersection.		
5400	5686	Full intersection with give way sign and vehicles crossing from the right following curved road.	Full intersection with give way sign and vehicles crossing from the left following curved road.	300 metres prior	250 metres prior
6500	6250	End of Drive B	End of Drive B		

The drives employed in Experiment 2 are detailed in Table 3 (Drive A) and Table 4 (Drive B). They differ slightly from the drives employed in Experiment 1, because Experiment 1 was in fact conducted second and so incorporated some refinements. For Drive A, Experiment 2 differs from Experiment 1 in that the pedestrian emerges from a different location, no vehicle approaches from behind after the pedestrian event, the first curve is to the right, there is no sign indicating the first intersection, the second curve is replaced by a hill, there is no sign indicating the second intersection, and vehicles approach from the right at the second intersection. For Drive B, Experiment 2 differs from Experiment 1 in that 6 pedestrians emerge from a different location.

Further, data recording differs somewhat from Experiment 1. Rather than recording for the entire drive, the program recorded data only for the sections of the drive detailed in Tables 3 and 4. Mean speed for the entire drive was computed as the distance covered during the drive divided by the time taken to complete it (both recorded as a default). Mean lateral position for the entire drive was the average of the lateral position recorded during each section. Speed exceedances was computed as the sum of exceedances recorded during the whole drive. Red lights ran and collisions are recorded for the entire drive as a default, and were treated as proportion of total events for the duration of the drive. Otherwise treatment of variables is parallel to Experiment 1.

All drives were kept relatively short (approximately 5 minutes), in order to minimize motion sickness due to the absence of g-forces.

Laptop PC and software

A laptop PC was employed to present all visual and audio materials. The PC had a 14” monitor, which is approximately the size of seat-back units that are currently being retailed.

A digital sound editor, Cool Edit Pro, was used to administer the audio materials in Experiment 1. This software was also employed to set the specifications of the audio material (see Tables 5 and 6).

Sound pressure level metre

A hand-held “Radio Shack” sound pressure level meter was used to obtain an estimate of the relative volumes of the audiovisual and radio sound sources. This meter measures sound pressures in an acoustic environment in the range 50-126dB, and is designed specifically to mimic the operation of the human ear.

Audiovisual material

Experiment 1- Visual material

The visual materials presented during the relevant conditions were excerpts from a film that would be likely to be viewed by children (who most often travel in the rear of a car). The film, *The Indian in the Cupboard*, was selected to be unfamiliar to most participants, because familiar material (for example, a popular film like *Shrek*) may be easier to comprehend with minimal attention. Three different excerpts were employed.

Experiment 2- Audio material

For the duration of the “audio material presented” drives, one of two soundtracks were presented employing a laptop that was positioned in the boot of the car:

1. The soundtrack of a film that would be likely to be viewed by children (who most often travel in the rear of a car). The film, *The Iron Giant*, was selected again to be unfamiliar to most participants. Speakers were positioned on the back of the front seats and directed toward the rear of the car to mimic the real-world situation of having seat-back audiovisual display units. The volume was set at a level that is comfortable for someone sitting in the back of the car. This was readily audible to the driver. At approximately the position of the drivers’ head, the sound level averaged 70.56 dB(A) (s.d..= 1.47, over 8 recordings made every 30s).
2. The soundtrack of a talk-back radio program; because this is material that is commonly listened to and has something of a “story” (and so some comparability with the film soundtrack). Speakers were positioned in the front of the car and directed toward the rear of the car to mimic the real-world situation of having a radio playing in the drviers’ seat. The volume was set at a level that is comfortable for someone sitting in the front of the car. At approximately the position of the drivers’ head, the sound level averaged 68.94 dB(A) (s.d.= 0.56, over 8 recordings made every 30s). The parameters that were set using are shown in Table 6.

There are numerous differences between these two conditions, and thus it is not possible to isolate a specific cause of differences in distraction caused by the two conditions. However, the aim of the present experiment is not to isolate the causes of distraction, but rather to establish the level of distraction that is produced by different sounds *as they would typically be encountered whilst driving.*

Participant Information Statement and Directions

Participants were sent (by email or post) a Participant Information Statement and directions to get to the simulator. The Participant Information Statement described the study, and the procedures involved similarly to the study advertisement [see Appendix A]. It also identified that some people experience motion sickness as a result of driving in the simulator, and that the sequence of drives involved in the experiment was designed to minimise this possibility. Participants were ensured that they were free to withdraw at any time and that all data collected is confidential.

Questionnaires

A brief, purpose-designed questionnaire [see Appendix B] asked participants about their experiences in the simulator, about their on-road experiences of audiovisual units, and about their personal characteristics (e.g. hours driving per week, years since receiving learners license, type of license currently held, date of birth, gender, highest level of education achieved, main language spoken at home, and postcode).

In relation to their experiences in the simulator, participants indicated whether they had previously seen or heard the audiovisual materials that were presented (Y/N; familiarity with the materials), as well as the extent to which they were distracted by the materials (perceived distraction, treated as an outcome measure) and the extent to which their driving was impaired by the materials (perceived impairment). These latter 2 items were answered on a fully-labelled Likert scale ranging from 1 (not at all) to 5 (very much).

In relation to their on-road experiences, participants indicated whether they had ever seen an in-vehicle TV/video/DVD or navigation system in a vehicle that they were not travelling in (Yes/No to each). Participants who responded in the affirmative were asked to think of the last occasion of seeing a display (specifying 1 of 6 timeframes), and to identify what it was and where it was positioned (back of front seats, suspended from roof in the rear, suspended from the roof in the front, on the instrument panel, other), whether they attended to it (on the fully-labelled Likert scale described earlier), and whether they remembered any details of what was on the display (Yes/No; if Yes asked details; regarded as an indicator of attention). They then indicated whether they had been a driver or a passenger on this occasion. Participants were then asked if they own, or have owned, a vehicle with an in-vehicle TV/video/DVD or navigation system. Participants who responded in the affirmative identified where the unit was positioned, and indicated the extent to which they would pay attention to it when driving (on the fully-labelled Likert scale described earlier).

A second questionnaire [see Appendix C] asked participants to identify the extent to which they agreed that they were motivated to participate because of getting 2 movie tickets, getting to use the driving simulator, of being interested in scientific research, and being interested in road safety research, each a fully-labelled Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Participants were asked to specify any other reason that they had for volunteering. They also indicated the relevance of a range of reasons for their availability during business hours (e.g. unemployed, shift work). This questionnaire provided some insight into possible selection biases.

A brief quiz [see Appendix D] was employed following the “instructed to attend” condition of Experiment 1 only, in order to assess whether this instruction was followed. It asked 4 rather obscure multiple-choice questions regarding the visual materials, each with 3 response options.

Movie tickets

Two tickets for Hoyts movie cinemas were provided to each participant to compensate for their time, effort, and travel expenses.

Procedure

Ethical approval was obtained from the Human Ethics Secretariat at UNSW. The simulator drives programs, audiovisual materials, questionnaires, and procedures were piloted.

Advertisements were posted on and around UNSW Kensington campus, and in the *Southern Courier*. Volunteers called a contact number to make an appointment to participate, and were sent (either by email, or by post) a Participant Information Statement and directions to get to the simulator.

Each participant was tested separately in the room that houses the driving simulator. When each participant arrived the experimenter reminded him/her of the information from the Participant Information Statement. In particular s/he was reminded of the possibility of simulator sickness and that s/he could stop at any time.

Participants were then given a verbal explanation of the details of the procedure according to a standard script, and were asked to sign a consent form. Instructions were also given according to a standard script at each stage of the experiments.

Participants were then seated in the vehicle and asked to adjust the seat to the desired position. They were alerted to the part of the screen that operates as a rear view mirror[3].

Practice drive(s)

In Experiment 1, participants were required to complete two practice drives, each 1.55 kilometres in length. These drives gave participants an opportunity to practice controlling the vehicle and responding to traffic lights, pedestrians, cross traffic, and corners. Participants were told: “drive as if you need to get to work on

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[3] In Experiment 1 only. This feature was not activated in Experiment 2 (which was in fact conducted first).

time. However, you must stick to the road rules at all times. The road rules are just like on the real road: there are speed signs you must stick to, give way signs mean you give way to traffic at and intersection and so forth. During the drives don't make any right- or left-hand turns, just drive straight ahead". Participants were advised to experiment with different speeds, and with braking. Data was recorded throughout the second practice drive.

The practice drive was somewhat simpler in Experiment 2 than in Experiment 1 (which was in fact conducted second). Participants adapted to the car controls and simulated environment by stopping regularly at a series of intersections with give way signs. At the end of the first practice drive participants were asked if they felt they had adjusted to driving the simulator at the end of the first practice drive, and offered the opportunity of completing a second practice drive. Approximately 99.9% of participants took this opportunity (resulting to the mandatory second practice Drive in Experiment 1).

Test drives

After the practice drive(s) participants completed the test drives according to the counterbalance orders outlined in the Design section [see Tables 1 and 2]. Within each experiment, each counterbalance group was filled approximately in tandem (to control for time of year effects).

Before each of the test drives, participants were instructed "For this drive the idea is the same as the first drive; drive as though you are trying to get to work, stick to the road rules, and don't make any right- or left-hand turns, just drive straight ahead."

In Experiment 1, for the first audiovisual drive (for all conditions except the "No instruction" condition), participants were told that there would be a movie playing on the laptop. For subsequent audiovisual drives they were told that there would be a movie playing again. In the "instructed to ignore" condition participants were told "I want you to completely ignore [the movie] and focus on your driving only." In the "instructed to attend" condition participants were told "I want you to pay attention to [the movie] whilst you drive, remembering to stick to the road rules at all times. I will give you a short multiple-choice quiz, which asks about what happened in the movie, at the end of the drive." Naturally, in the "no instruction" condition, participants were given no instructions relating to attention. After the "instructed to attend" conditions participants completed the brief quiz assessing attention, and after they had completed all the drives, half of participants[4] were asked to think back to the condition in which they were given no instructions and asked whether they thought they were supposed to attend to, or ignore, the film.

In Experiment 2, before the radio and audiovisual conditions, participants were informed that there would be radio sound coming from the front of the vehicle or

[4] This procedural detail was only introduced about half way through data collection for Experiment 1.

the sound of a movie coming from the rear of the vehicle, respectively. The need for this instruction became apparent when early participants indicated (on the audiovisual questionnaire) that they had no recollection of a movie playing during any of the simulated test drives, possibly taking it to be associated with construction noise that could be heard from another room.

Data was recorded throughout the test drives.

Each test drive took approximately 5 minutes (depending on the driver's speed), and a 1-2 minute break was allowed between drives, to reduce the possibility of motion sickness.

After completing all test drives on the driving simulator (4 in Experiment 1, and 3 in Experiment 2), participants completed the questionnaire regarding their experience of in-car audiovisual entertainment systems and the questionnaire regarding their motivations for participating.

Participants were then debriefed, and given their 2 movie tickets.

Experiment 1 sessions lasted approximately 1 hour, and Experiment 2 sessions lasted approximately 45 minutes.

Table 5 summarised the procedures of both Experiment 1 and Experiment 2.

Table 5 Summary of procedures for Experiment 1 and Experiment 2

Experiment 1	**Experiment 2**
Participant Information Statement, and consent	Participant Information Statement, and consent
Instructions for practice drives; 2 practice drives	Instructions for practice drives; 1 or 2 practice drives
Instructions for test drives, before each 4 test drives (order counterbalanced) 1. Visual materials presented; instructed to ignore 2. Visual materials presented; instructed to attend *and followed by multiple-choice questions regarding material* 3. Visual materials presented; no instruction 4. Control (no visual materials presented)	Instructions for test drives, before each 3 test drives (order counterbalanced) 1. Audio materials from audiovisual program presented 2. Audio materials from radio presented 3. Control (no audio materials presented)
Questionnaires regarding experiences in the simulator, on-road experience of in-vehicle audiovisual display units, personal characteristics, and reasons for attending	Questionnaires regarding experiences in the simulator, on-road experience of in-vehicle audiovisual display units, personal characteristics, and reasons for attending
Debrief and movie ticket	Debrief and movie ticket

Statistical analysis

All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS). For all statistical comparisons a Type I error rate of .05 was adopted. The same planned contrast for all simulator-derived variables was treated as a family of tests, and an effect (e.g. of condition) only deemed "real" if the number of significant effects in the family of tests exceeded that which could be expected by twice chance.

Sample Descriptives

Descriptive analyses were conducted to characterise the sample for both Experiment 1 and Experiment 2.

Aim 1

To examine whether drivers are likely to attend to the visual materials of an audiovisual program from a unit that is visible from the back of another vehicle, descriptive data are reported for relevant variables from the questionnaires.

Aim 2- Experiment 1

To examine whether the visual materials of an audiovisual program from a unit positioned as a front seat-back display in another vehicle impairs driving performance, the planned comparisons outlined in Table 6 were made using a repeated measures ANOVA for each continuous dependent simulator variable [see Dependent Variables section below].

Table 6: Contrasts conducted to address Aim 2 [Experiment 1]

Contrast #		**Condition**			**Contrast meaning**
	Visual material: ignore	Visual material: attend	Visual material: no instruction	Control	
1	1	0	0	-1	Effect of A/V under implicit road conditions
2	0	1	0	-1	Effect of A/V when watched
3	0	0	1	-1	Effect of A/V under exact road conditions

Within each condition, correlation of each dependent variable with age in years, gender, education, ethnicity, years since learner's license obtained, self-reported mean number of hours spent driving per week, self-reported familiarity with the audio materials, and practice drive performance variables were computed. Practice drive performance variables were treated as potential covariates. They were included in any of the above comparisons if found to be related to the dependent variable in either condition involved in the comparison. Relationships in the control condition, reflect an association of the potential covariate with driving performance, whereas relationships in other conditions reflect an association of the potential covariate either with driving performance or with the ability of the audiovisual materials to impact driving performance.

For dichotomous dependent variables [see Dependent Variables section below] Chi-squares were structured to make the same comparisons.

Aim 3- Experiment 2

To examine whether the audio materials of an audiovisual program from a unit positioned in the back of the vehicle (so that it cannot be seen) impairs driving performance, the planned comparisons outlined in Table 7 were made using a repeated measures ANOVA for all continuous dependent variables [see Dependent Variables section below].

Table 7: Contrasts conducted to address Aim 3 [Experiment 2]

Contrast #		**Condition**		**Contrast description**
	Audiovisual	Radio	Control	
1	1	0	-1	Effect of A/V
2	0	1	-1	Effect of radio

Within each condition, correlation of each dependent variable with age in years, gender, education, ethnicity, years since learner's license obtained, self-reported mean number of hours spent driving per week, self-reported familiarity with the audio materials, and practice drive performance variables were computed. Practice drive performance variables were not measured in this experiment, so could not be treated as potential covariates.

Again, for dichotomous dependent variables [see Dependent Variables section below] Chi-squares were structured to make the same comparisons.

Dependent variables

Simulator-derived dependent variables

Table 8 provides a thorough description of the simulator-derived dependent variables in terms of operationalisation, rationale and type.

Table 8: Simulator-derived dependent variables, operationalisation, rationale, and type.

Simulator variable	Operationalisation	Rationale	Type	Experiment
Mean speed (km/hr)	Longitudinal velocity.	Lower speed may reflect compensation	Continuous	1 and 2
Deceleration (m/s)	Rate of change in longitudinal velocity.	In response to hazards, lower deceleration may reflect inattention or high reaction time.	Continuous	1 and 2
Mean lateral position (metres)	The lane position of the car-centre in relation to the roadway line marking that separates the driver's lane from oncoming traffic.	Greater deviation may reflect inattention or poor vehicle control	Continuous	1 and 2
Mean curvature error (1/m)	The deviation of the driving path from the actual curvature of the roadway, due to the steering inputs.	Greater error may reflect inattention or poor vehicle control	Continuous	1
Mean road heading error (radians)	Similar to curvature error, the deviation of the driving heading angle of the driver from the actual heading angle of the roadway.	Greater error may reflect inattention or poor vehicle control	Continuous	1
SD acceleration (g's)	Variability of the total acceleration due to throttle input, breaking, and drag.	Greater variability reflects inattention or poor vehicle control	Continuous	1
SD throttle input (g's/s)	Variability in throttle input.	Greater variability reflects inattention or poor vehicle control	Continuous	1
SD lateral position (metres)	Variability in lane position.	Greater variability reflects inattention or poor vehicle control	Continuous	1 and 2
SD steering wheel rate (deg/sec)	Variability of the speed at which the driver turns the steering wheel during a turning manoeuvre.	Greater variability reflects inattention or poor vehicle control	Continuous	1

Simulator variable	Operationalisation	Rationale	Type	Experiment
SD curvature error (1/m)	Variability in the deviation of driving path.	Greater variability reflects inattention or poor vehicle control	Continuous	1
SD road heading error (radians)	Variability in the deviation of heading angle.	Greater variability reflects inattention or poor vehicle control	Continuous	1
Speed exceedances	The number of times the driver exceeds the speed limit indicated by the last speed sign.	Greater variability reflects inattention or poor vehicle control	Continuous	1 and 2
Traffic lights ran	The number of times the driver crosses the signal limit line after the lights have turned red.	Greater variability reflects inattention or poor vehicle control	Recoded as dichotomous[a]	1 and 2
Collision with pedestrians	The number of pedestrians that are hit.	Greater variability reflects inattention or poor vehicle control	Recoded as dichotomous[a]	1 and 2
Collisions with other vehicles	The number of collisions with other vehicles on the road (including vehicles in the same lane, oncoming and cross traffic and vehicles shown in the rear view mirror).	Greater variability reflects inattention or poor vehicle control	Recoded as dichotomous[a]	1 and 2
Off road crashes	The number of times the driver steers off the road by 2m in Experiment 1, and 0.5m in Experiment 2	Greater variability reflects inattention or poor vehicle control	Recoded as dichotomous[a]	1 and 2

[a] Recoded as dichotomous because of low count data

Mean speed was computed

a) for the total drive;
b) approaching each traffic light, as an indicator of awareness of each potential hazard;
c) approaching traffic lights 1 and 3 (excluding of traffic light 2 because of its long amber duration);

d) approaching each curve/intersection, as an indicator of awareness of each potential hazard;
e) approaching all curve/intersections together;
f) approaching the pedestrian(s)

Tables 3 and 4 provide information about the length of sections for which speed was computed separately.

Deceleration approaching the pedestrian was calculated in two ways. The program gathered speed data .049 times a second. From this record, data was extracted 10 seconds prior to the point at which the driver had reached the location of the pedestrian (resulting in approximately 204 data points).
The initial speed, for both methods of calculating deceleration, was determined according to the speed the driver was travelling 10 seconds prior to reaching the pedestrian (i.e., the first data point from the extracted data). One method for determining final speed was to determine each driver's minimum speed and the time taken to reach minimum speed in this 10 second time. The other method for determining final speed, was to calculate the mean minimum speed for all drivers, across all conditions, to find a constant portion of this time frame for which deceleration could be examined (i.e., from 10 seconds before reaching the pedestrian to the point at which drivers, on average, reached their minimum speed).

In Experiment 1 only (because of an oddity with the placement of the limit line at traffic lights), a driver was coded as "stopped" at traffic lights if their speed was less than 10 km/hr 10 metres prior to the location of the traffic lights (and "ran" otherwise).

There were slight differences in the computation of dependent variables for Experiments 1 and 2, because of slight differences in recorded data. Further, some variables were computed slightly differently for Drive A compared to Drive B (within each Experiment).

Questionnaire-derived dependent variables

Perceived distraction, and perceived impairment, produced by visual or audio material (both measured in relation to all audiovisual conditions overall, on a 5-point scale) were also treated as continuous dependent variables.

Results

Sample description

Table 9 presents descriptive information regarding the personal characteristics, driving experience, and motivation for involvement, of the samples employed for Experiments 1 and 2

Table 9: Description of sample for Experiment 1 and Experiment 2

Characteristic	Experiment 1 Number (%)	Experiment 2 Number (%)
Age (years)		
<30	7 (25.0)	6 (22.2)
30-39	6 (21.4)	12 (44.4)
40-50	7 (25.0)	3 (11.1)
>50	8 (28.6)	6 (22.2)
Sex		
Female	14 (50.0)	12 (44.4)
Male	14 (50.0)	15 (55.6)
Highest level of education		
School certificate	5 (17.9)	2 (7.4)
HSC	2 (7.1)	1 (3.7)
Tertiary	21 (75.0)	24 (88.9)
Main language spoken at home		
English	25 (89.3)	24 (88.9)
Chinese	1 (3.6)	1 (3.7)
Russian	1 (3.6)	1 (3.7)
Sri Lankan	1 (3.6)	1 (3.7)
Type of driver's license held		
Full license	25 (89.3)	26 (96.3)
Green P-plates	2 (7.1)	1 (3.7)
License disqualified	1 (3.6)	0 (0.0)
Years since Learner's obtained		
<10	4 (14.3)	3 (11.1)
10-19	9 (32.1)	12 (44.4)
20-29	7 (25.0)	7 (25.9)
30-40	5 (17.9)	2 (7.4)
>40	3 (10.7)	3 (11.1)
Mean (SD)	*22.1 (12.40)*	*20.87 (12.13)*
Mean number of hours spent driving each week		
<5	8 (28.6)	6 (22.2)
5-9	6 (21.4)	6 (22.2)
10-14	7 (25.0)	4 (14.8)
15-20	6 (21.4)	8 (29.6)
>20	1 (3.6)	3 (11.1)
Mean (SD)	*9.82 (6.54)*	*13.26 (11.48)*

Characteristic	Experiment 1 Number (%)	Experiment 2 Number (%)
Familiarity with visual content		
Familiar	9 (32.1)	7 (25.9)
Unfamiliar	19 (67.9)	18 (66.7)
Did not notice	N/A	2 (7.4)
Familiarity with audio content		
Familiar	N/A	4 (14.8)
Unfamiliar	N/A	20 (74.1)
Did not notice	N/A	3 (11.1)
Motivated by movie tickets		
Disagree (<4)	3 (13.6)	4 (16.0)
Neutral (=4)	2 (9.1)	1 (4.0)
Agree (>4)	17 (77.3)	20 (80.0)
Motivated by simulator		
Disagree	5 (21.7)	8 (33.3)
Neutral	4 (17.4)	2 (8.3)
Agree	14 (60.9)	14 (58.3)
Motivated by road safety		
Disagree	4 (17.4)	5 (19.2)
Neutral	1 (4.3)	2 (7.7)
Agree	18 (78.3)	19 (73.1)
Motivated by science		
Disagree	1 (4.3)	4 (16.0)
Neutral	4 (17.4)	5 (20.0)
Agree	18 (78.3)	16 (64.0)
Reasons for availability		
Flexible working hours	7 (33.3)	9 (34.6)
Holiday	3 (14.3)	7 (26.9)
Unemployed	2 (9.5)	5 (19.2)
Other	9 (43.0)	5 (19.2)

The samples recruited for Experiments 1 and 2 were very similar.

Both samples demonstrated a good distribution of age, gender, years since learners license was obtained, and mean hours spend driving each week. These variables were treated as potential covariates in later analysis.

Both samples were biased in favour of higher education and English-speakers (as might be predicted given the recruitment techniques), and this should be considered in generalising results.

The vast majority of participants held full licenses.

As hoped, most participants were unfamiliar with the audiovisual materials employed in the study.

Most participants agreed that all four nominated factors motivated them to participate in the study. Flexible work hours was commonly cited as a reason for their availability to participate.

Aim 1- Questionnaire

In order to examine respondents' on-road experience of audiovisual, or navigation system, display units, and the resulting distraction, relevant variables were analysed, across the samples from both Experiment 1 and Experiment 2 [see Table 10].

Table 10: Proportion of sample who reported sighting audiovisual or navigation system display units in other vehicles, and (as a proportion of sightings) the location and attention given [Experiment 1 and 2]

	Percentage of respondents sighting display	**Location of display**				**Average attention given to screen**			
		Dashboard	**Roof in front**	**Roof in rear**	**Back of front seats**	**Drivers**		**Passengers**	
						M	***SD***	***M***	***SD***
Audiovisual	26.2%	31.3%	*Nil*	37.5%	25.0%	2.75	0.96	3.00	0.89
Navigation	21.3%	25.0%	75.0%	*Nil*	*Nil*	2.50	0.58	2.50	0.58

Of all the survey respondents, 42.6% indicated that they had seen some kind of in-car audiovisual display unit in another vehicle, at one time or another, whilst travelling as a driver or passenger. In-vehicle audiovisual display units were most frequently sighted (26.2%), followed by in-vehicle navigation systems (21.3%). A smaller proportion of respondents (4.9%) said they had seen other kinds of in-vehicle display units (e.g., taxi driver information display system), and the remainder reported that they had never seen an in-vehicle audiovisual display unit whilst travelling as a driver or passenger.

All respondents who had seen an in-vehicle audiovisual display unit in another vehicle, were asked to identify where in the vehicle the display unit was located on the last occasion they had seen one. The in-car audiovisual display was seen in three locations: suspended from the roof in the rear (37.5%), on the dashboard (31.3%), and on the back of the front seats (25%). (The remaining participants could not recall the location of the audiovisual display.) In-vehicle navigation systems were either seen on the dashboard (75%) or suspended from the roof in the front of the other vehicle (25%).

80% of respondents who had seen an audiovisual display unit in another vehicle while they were driving reported that they paid at least “a little” attention to the last one they saw, with 40% paying “much” or “very much” attention (*M* = 2.8, *SD* = 0.96; on a scale from 1=not at all to 5=very much).

75.0% of respondents who had seen a navigation system in another vehicle while they were driving reported that they paid at least “a little” attention to the last one they saw, with the remainder paying “much” or “very much” attention to the display (*M* = 2.5, *SD* = 0.58; on a scale from 1=not at all to 5=very much).

Respondents who had seen an audiovisual display unit in another vehicle *while they were travelling as a passenger*, reported paying some attention to the display unit (audiovisual display unit: *M* = 3.0, *SD* = 0.96; navigation system: *M* = 2.5, *SD* = 0.58; on a scale from 1=not at all to 5=very much). 66.6% of passengers who had sighted an audiovisual display unit reported that they paid at least “a little” attention to the last one they saw, and 33.3% reported they paid much attention. All passengers who had sighted a navigation system reported that they paid at least “a little” attention to the last one they saw.

As a proportion of the respondents who had sighted a display of some kind, 46% said the last sighting was between one day and four weeks, the remainder having seen a display more than four weeks ago.

Only three respondents (4.9%) had ever owned an audiovisual display unit, and four (6.6%) had owned an in-vehicle navigation system. One of these audiovisual displays was installed on the roof in the front of the vehicle and the remaining two were fitted on the dashboard. Owners of audiovisual displays reported that while travelling in the vehicle they would pay some attention to the unit (*M* = 2.67, *SD* = 0.58).

Aim 2- Experiment 1

Preliminary analysis to check on response to instructions

In order to facilitate interpretation of results, participants’ response to the instructions was checked.

Fifteen participants in Experiment 1 were probed regarding their perceptions of experimenter demands during the “no instruction” condition. 80.0% of these participants reported thinking that the experimenter wanted them to ignore the screen. The remaining proportion was comprised of an equal number of responses indicating a perceived demand to drive as though in real-world conditions (6.7%), to engage in a combination of ignoring and attending to the screen (6.7%), and to attend to the screen (6.7%). Thus, it can be assumed that in the “no instruction” condition very few participants thought that they were to attend to the screen.

Scores on the five-item audiovisual quiz regarding the visual materials from the “instructed to attend” condition were high (*M* = 4.57, *SD* = 0.10), suggesting that during this condition participants did indeed attend to the visual materials.

It is perhaps reasonable to assume that if participants followed the instruction to attend, then they also followed the instruction to ignore.

Primary analysis of continuous simulator-derived dependent variables

The planned analysis described in the Statistical Analysis section was conducted for all continuous simulator-derived dependent variables [see Table 11].

Table 11: Means, standard deviations, and planned contrast analyses for all simulator-derived continuous dependent variables

Simulator variable	**Event**	**Means and standard deviations**								**Planned contrast analyses**					
		Ignore		**Attend**		**No instruction**		**Control**		**Ignore vs. control**		**Attend vs. control**		**No instruction vs. control**	
		Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***	***F***	***p***	***F***	***p***	***F***	***p***
Mean speed (km/hr)	**Total drive**	60.84	5.74	56.94	9.42	59.73	5.80	61.01	6.11	0.06	.814	13.50	.001**	2.66	.114
	Traffic 1	68.20	10.51	62.39	15.68	64.84	10.96	67.09	10.05	0.36	.553	3.93	.058	2.31	.140
	Traffic 2	54.99	11.20	53.95	12.69	53.90	9.87	53.03	9.32	0.61	.442	0.14	.714	0.13	.723
	Traffic 3	65.76	10.40	61.65	13.70	65.70	11.84	65.76	9.48	<.001	.999	4.15	.052	.001	.974
	Traffic all	62.98	8.22	59.33	12.75	61.48	9.41	61.96	7.88	0.60	.446	2.11	.158	0.12	.731
	Traffic 1 and 3	66.98	8.67	62.02	14.21	65.27	10.97	66.42	8.96	0.21	.648	5.14	.032*	0.65	.428
	Cross traffic 1	55.74	9.03	53.42	9.13	54.78	6.47	53.40	8.54	1.84	.186	0.00	.987	1.11	.302
	Cross traffic 2	55.91	6.10	55.61	9.84	55.69	6.90	54.34	6.16	1.56	.222	0.90	.354	2.11	.158
	Cross traffic all	55.82	7.39	54.52	8.91	55.23	6.12	53.87	6.90	2.11	.158	0.37	.550	2.63	.117
	Pedestrian	13.70	4.42	11.59	4.98	12.45	3.82	12.58	3.44	3.06	.091	2.82	.105	0.07	.800
Deceleration (m/s)	**Pedestrian *(a)***	-2.45	1.34	-2.74	1.64	-2.73	0.10	-2.69	1.10	0.69	.414	0.02	.892	0.02	.892
	Pedestrian *(b)*	-1.67	0.94	-1.34	0.94	-1.98	1.04	-2.10	0.89	2.59	.119	11.26	.002**	0.28	.604
Mean lateral position (metres)	**Total drive**	-2.01	0.81	-2.24	0.25	-2.20	0.19	-2.17	0.21	1.14	.295	3.93	.058	0.46	.503
	Final block	-2.12	0.25	-2.23	0.24	-2.17	0.20	-2.15	0.21	0.92	.346	4.60	.041*	0.20	.657
Mean curvature error (1/m)	**Total drive**	2.19^{-4}	4.77^{-5}	2.08^{-4}	7.30^{-5}	2.25^{-4}	5.78^{-5}	2.13^{-4}	6.46^{-4}	0.10	.757	0.32	.579	0.40	.532

Simulator variable	Event	Means and standard deviations								Planned contrast analyses					
		Ignore		Attend		No instruction		Control		Ignore vs. control		Attend vs. control		No instruction vs. control	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*F*	*p*	*F*	*p*	*F*	*p*
Mean road heading error (radians)	**Total drive**	12.51	0.66	12.38	0.70	12.61	0.66	12.55	0.49	0.11	.747	0.99	.329	0.20	.655
SD acceleration (g's)	**Total drive**	0.12	0.02	0.12	0.03	0.12	0.02	0.12	0.02	0.07	.787	0.10	.759	0.00	1.000
SD throttle input (g's/s)	**Total drive**	0.20	0.05	0.20	0.04	0.21	0.05	0.21	0.06	2.20	.150	2.23	.147	0.25	.618
SD lateral position (metres)	**Total drive**	0.30	0.07	0.30	0.07	0.30	0.07	0.30	0.05	0.21	.653	0.25	.619	0.03	.855
	Final block	0.28	0.08	0.29	0.10	0.27	0.08	0.26	0.08	1.48	.234	9.01	.006**	0.26	.616
SD steering wheel rate (deg/sec)	**Total drive**	5.00	2.30	5.61	1.94	6.35	4.16	5.38	2.40	0.75	.393	0.38	.543	3.97	.056
SD curvature error (1/m)	**Total drive**	7.31^{-4}	1.57^{-4}	7.85^{-4}	1.70^{-4}	7.92^{-4}	3.09^{-4}	7.63^{-4}	1.42^{-4}	1.62	.214	0.71	.408	0.43	.517
SD road heading error (radians)	**Total drive**	20.96	0.51	20.85	0.59	21.03	0.60	20.95	0.47	0.00	.950	0.57	.455	0.51	.480
Speed exceedance	**Total drive**	6.75	4.12	6.14	5.09	6.75	5.13	7.57	5.65	2.28	.143	3.81	.061	1.81	.190

**Significant at .05 level.*
***Significant at .01 level.*

Mean speed for total drive was significantly lower when drivers were instructed to attend to the screen, compared with the control condition. Mean speed approaching the first and third set of traffic lights (each having a 3s amber rather than the 9s amber employed in traffic light 2) *combined* was also lower in the "instructed to attend" than in the control condition. The same comparison just failed to reach significance for the first and third traffic lights treated separately (p=.058, and p=.052, respectively).

When confronted by the second pedestrian drivers who were instructed to attend to the screen decelerated at a slower rate (from the time the pedestrian appeared to the average minimum speed for all drivers across conditions) compared with the control condition.

Drivers who were instructed to attend to the screen kept a mean lane position that was further to the left of the lane on a curvy section of road (compared to the control condition), and this reflects worse performance because in each condition mean lane position was left of the lane-centre (indicated by a score of -2). The same comparison just failed to reach significance when the total drive was considered (p=.058).

Lane position was more variable on a curvy section of road in the "instructed to attend" than in the control condition.

No further significant differences were observed.

The number of effects observed for the "instructed to attend" versus control condition is well beyond that which could be expected by twice chance. Figures 3 to 7 depict condition means for variables that showed a significant difference between the "instructed to attend" and control conditions.

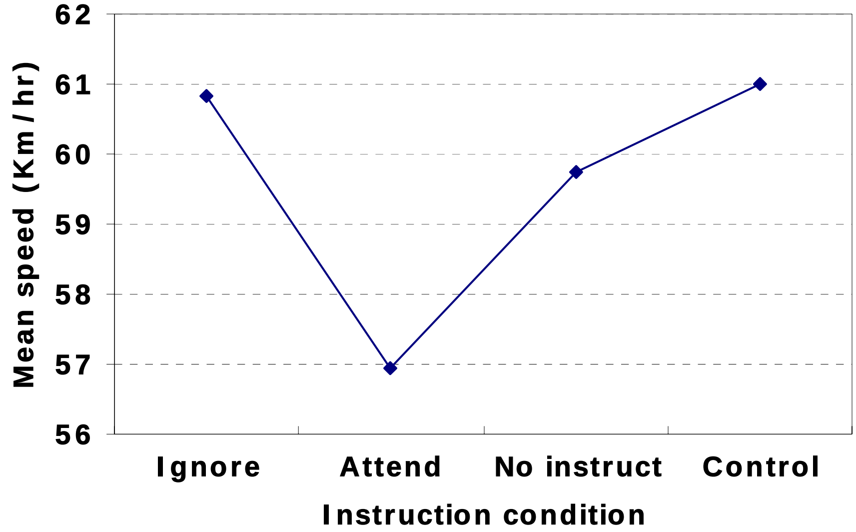

Figure 3: Mean speed for total drive

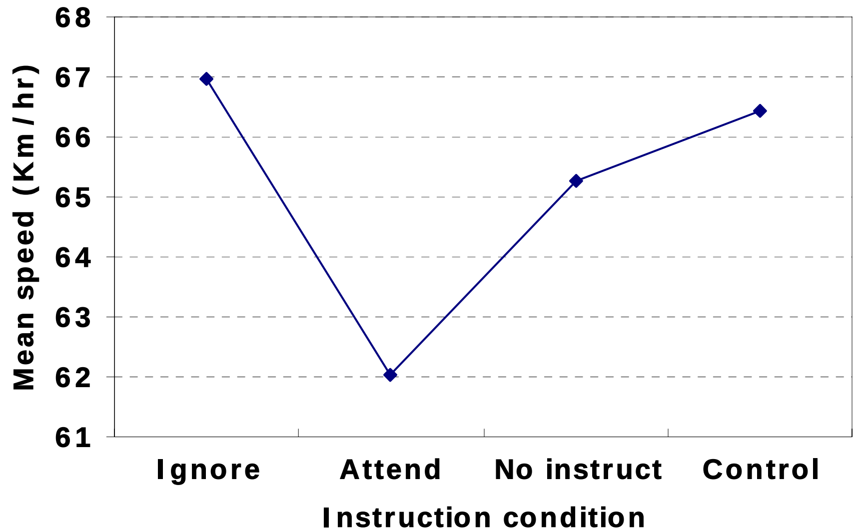

Figure 4: Mean speed approaching Traffic 1 and 3 combined

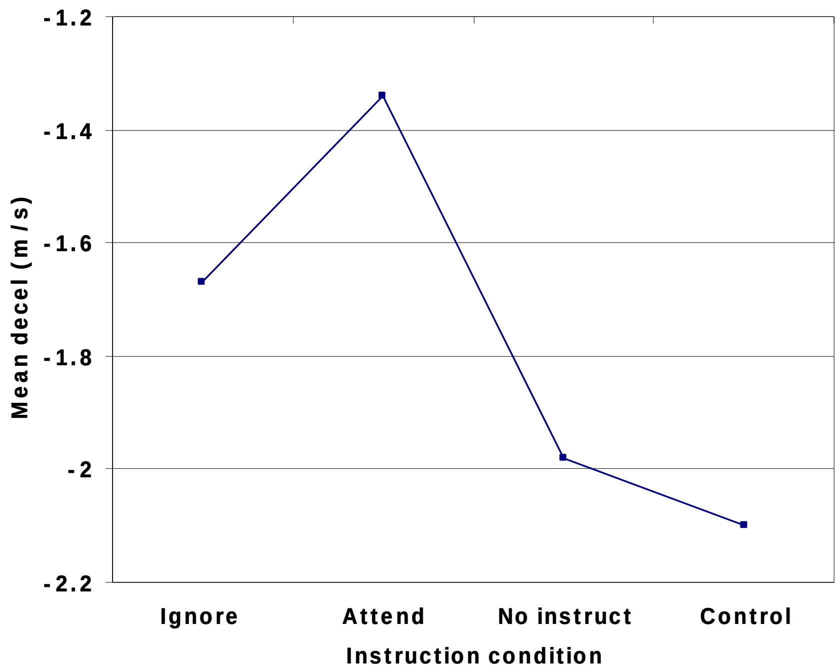

Figure 5: Mean deceleration approaching pedestrian

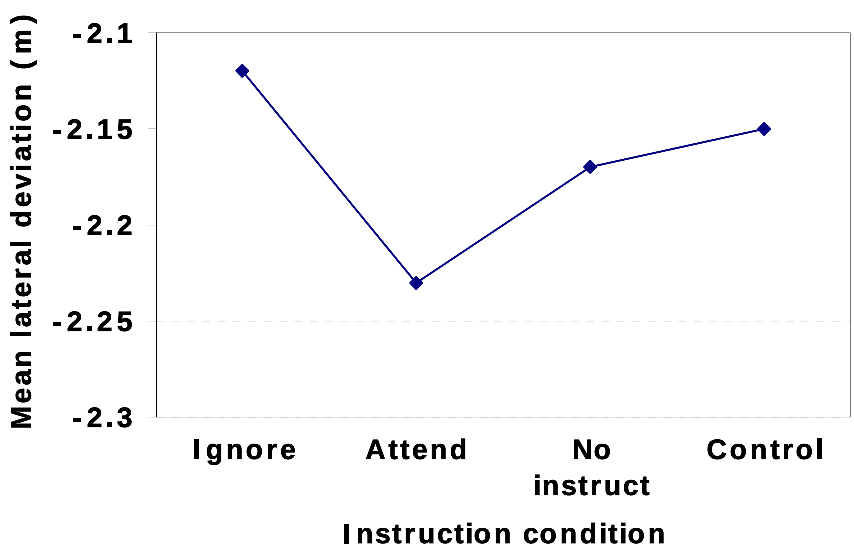

Figure 6: Mean lateral position for curvy road section

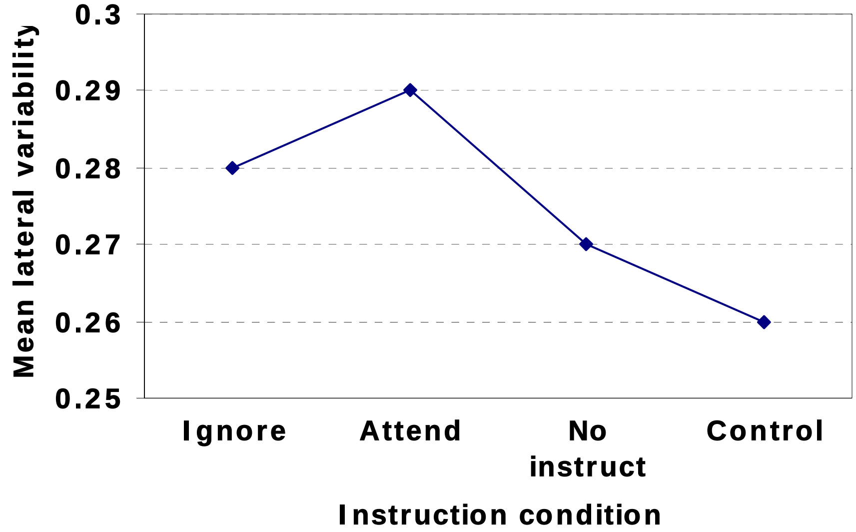

Figure 7: Mean variability in lateral position for curvy road section

Correlations of each continuous simulator-derived dependent variable with personal characteristics

Pearson product-moment correlations of each dependent variable with questionnaire-measured personal characteristics, driving experience, and motivation for involvement were computed within each condition (see Tables 12 to 14). Further, in order to examine which covariates should be incorporated in further analyses, correlations of each simulator-derived continuous dependent variable with "corresponding" measures of driving performance during the second practice drive were computed (see Table 13). For deceleration approaching pedestrians, the corresponding practice drive measure was deceleration approaching the last pedestrian encountered. For other dependent variables, the corresponding practice drive measure was computed over the entire practice drive.

Table 13 indicates moderate to strong relationships between most simulator variables taken in the practice session and driving performance in the experimental conditions.

Table 12: Correlation of each simulator-derived continuous dependent variable with personal characteristics

Simulator variable	**Event**	**Age**				**Gender**				**Education**				**Language**			
		Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control
Mean speed (km/hr)	**Total drive**	-.314	-.263	-.391*	-.293	-.344	-.346	-.286	-.168	.182	.238	-.391	.322	-.100	-.095	-.102	-.090
	Traffic 1	-.161	-.414*	-.484*	-.512*	.027	-.278	-.322	-.051	-.300	.235	.087	.403*	-.133	-.139	-.075	-.013
	Traffic 2	-.089	-.198	-.188	-.145	-.319	-.200	-.175	-.106	.230	.217	.211	.090	.187	-.048	.199	.071
	Traffic 3	-.323	-.356	-.529*	-.243	-.341	-.349	-.476	-.014	.314	.218	.321	.001	.190	-.068	.167	-.122
	Traffic all	-.245	-.363	-.4768	-.372	-.277	-.305	-.386*	-.069	.109	.247	.242	.207	.108	-.097	.111	-.026
	Traffic 1 and 3	-.291	-.400*	-.528*	-.416*	-.188	-.321	-.418	-.036	.007	.235	.216	.226	.034	-.110	.053	-.072
	Cross traffic 1	-.255	-.353	-.341	-.313	-.116	-.287	-.212	-.173	.155	.303	.232	.316	-.104	.005	-.049	.112
	Cross traffic 2	-.188	-.287	-.341	-.130	-.122	-.320	-.302	-.319	.230	.283	.489	.414	-.039	-.016	.052	.173
	Cross traffic all	-.245	-.339	-.372	-.251	-.128	-.324	-.282	-.250	.204	.311	.398	.381	-.082	-.006	.004	.146
	Pedestrian	-.565*	-.236	-.285	.095	-.153	-.270	-.145	-.379	.103	.540	-.073	.349	.089	.108	-.310	.316
Deceleration (m/s)	**Pedestrian *(a)***	-.150	-.092	-.133	.196	-.075	-.226	-.037	-.351	-.079	.122	-.097	.281	-.350	.228	-.274	.332
	Pedestrian *(b)*	-.477*	-.169	-.256	.492**	-.017	-.078	.116	-.104	-.179	.179	-.044	-.066	-.184	.178	-.179	.238

Simulator variable	Event	Age				Gender				Education				Language			
		Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control
Mean lateral deviation (metres)	**Total drive**	-.112	-.061	-.182	-.196	.240	.087	.077	-.041	.123	.283	.284	.282	-.082	-.293	-.081	.103
	Final block	-.060	.092	.085	-.280	.302	-.077	.058	.071	.078	.196	.229	.228	-.186	-.246	-.193	.010
Mean curvature error (1/m)	**Total drive**	-.305	.270	.208	.085	-.289	.121	.085	.166	-.099	-.035	-.243	.093	.162	.019	-.367	-.080
Mean road heading error (radians)	**Total drive**	-.224	-.429*	-.422*	-.443*	-.130	-.178	-.241	.086	-.259	.294	.048	.049	-.092	.073	.222	-.178
SD acceleration (g's)	**Total drive**	-.122	-.124	.192	-.144	-.096	-.079	087	-.113	.113	.037	.010	-.116	.022	-.081	-.073	-.041
SD throttle input (g's/s)	**Total drive**	.099	.093	.173	-.102	.068	<.001	.208	-.097	.251	.060	.269	.105	-.209	-.084	-.250	-.246
SD lateral deviation (metres)	**Total drive**	-.535*	-.416*	-.360	-.334	-.061	.093	-.134	.092	.334	-.060	.190	.066	.229	-.003	.222	-.009
	Final block	-.560*	-.498**	-.494*	-.498**	.106	-.050	-.327	.174	.385*	.096	.455	-.155	.034	-.023	.137	-.202
SD steering wheel rate (deg/sec)	**Total drive**	.259	.442*	.263	.281	-.099	-.055	-.215	-.213	.083	-.088	.035	-.109	.201	.274	.157	.191
SD curvature error (1/m)	**Total drive**	.429*	.429*	.400*	.359	.165	.113	.113	-.254	-.028	.042	.042	-.022	.172	.021	.021	.157
SD road heading error (radians)	**Total drive**	-.332	-.345	-.560*	-.350	-.272	-.326	-.238	-.189	-.069	.365	.220	.146	-.026	.335	.347	.151
Speed exceedances	**Total drive**	-.300	-.283	-.276	-.358	-.097	-.100	-.135	-.090	-.102	.016	.201	.107	-.169	-.127	-.254	-.130

**Significant at .05 level.*
***Significant at.01 level.*

Table 13: Correlation of each simulator-derived continuous dependent variable with each driving ability measure (including corresponding practice drive variables)

Simulator variable	Event	Years since Learner's obtained				Mean number of hours driving each week				Corresponding practice drive measure			
		Ignore	Attend	No instruction	Control	Ignore	Attend	No instruction	Control	Ignore	Attend	No instruction	Control
Mean speed (km/hr)	**Total drive**	-.270	-.225	-.355	-.266	-.229	-.411*	-.236	-.464*	.586**	.671**	.623**	.669**
	Traffic 1	-.111	-.367	-.440*	-.487*	-.351	-.291	-.149	-.311	.292	.673**	.709**	.534**
	Traffic 2	-.117	-.205	-.245	-.152	.076	-.438	-.125	-.077	.241	.321	.183	.274
	Traffic 3	-.324	-.318	-.546*	-.205	-.120	-.324	-.064	-.519**	.529**	.572**	.717**	.490**
	Traffic all	-.237	-.333	-.486*	-.349	-.165	-.381*	-.128	-.371	.469**	.584**	.649**	.525**
	Traffic 1 and 3	-.261	-.356	-.515	-.381	-.283	-.317	-.109	-.449*	.496**	.648**	.742**	.560**
	Cross traffic 1	-.226	-.333	-.288	-.347	-.139	-.357	-.261	-.382*	.259	.546**	.521**	.539**
	Cross traffic 2	-.186	-.302	-.343	-.187	.001	-.318	-.302	-.166	.078	.483*	.522**	.312
	Cross traffic all	-.226	-.338	-.345	-.298	-.085	-.358	-.308	-.311	.196	.546**	.571**	.474*
	Pedestrian	-.520**	-.243	-.212	-.002	-.059	-.398*	-.233	-.022	.558**	.659**	.549**	.300
Deceleration (m/s)	**Pedestrian *(a)***	-.098	-.118	-.048	.081	.084	-.044	-.142	.352	.217	-.088	.179	.281
	Pedestrian *(b)*	-.429	-.176	-.191	.400	.053	.186	.008	.154	.041	.028	.124	.274
Mean lateral position (metres)	**Total drive**	-.126	-.009	-.171	-.202	.217	.027	.089	.066	.322	.529**	.695**	.705**
	Final block	-.077	.145	.109	-.273	.128	.056	.106	.019	.343	.487**	.475**	.691**
Mean curvature error (1/m)	**Total drive**	-.323	.266	.294	.084	.146	.091	-.037	-.038	.742**	-.651**	-.229	-.547**
Mean road heading error (radians)	**Total drive**	-.156	-.383	-.394	-.365	.005	.019	.081	-.319	-.415*	.321	-.298	-.603**
SD acceleration (g's)	**Total drive**	-.183	-.170	.143	-.181	-.108	-.192	-.008	-.103	.661**	.823**	.713**	.671**
SD throttle input (g's/s)	**Total drive**	.109	.099	.179	-.064	-.206	-.004	-.018	-.059	.544**	.367	.567**	.435*

Simulator variable	Event	Years since Learner's obtained				Mean number of hours driving each week				Corresponding practice drive measure			
		Ignore	Attend	No instruction	Control	Ignore	Attend	No instruction	Control	Ignore	Attend	No instruction	Control
SD lateral position (metres)	**Total drive**	-.535**	-.389	-.338	-.301	-.032	.042	-.073	-.177	.345	-.027	.062	.084
	Final block	-.541**	-.487**	-.514**	-.434*	-.025	.171	.190	.024	.128	-.036	.380	.183
SD steering wheel rate (deg/sec)	**Total drive**	.171	.287	.227	.224	.132	.367	-.032	.040	.503**	.182	.521**	.229
SD curvature error (1/m)	**Total drive**	.156	.286	.341	.288	.117	.222	.035	.056	.734**	.768**	.905**	.500**
SD road heading error (radians)	**Total drive**	-.253	-.369	-.555**	-.347	-.143	.240	.169	-.297	-.393*	.348	-.165	-.672
Speed exceedances	**Total drive**	-.280	-.289	-.245	-.335	-.219	-.259	-.325	-.337	.627**	.601**	.692**	.770**

**Significant at .05 level.*
***Significant at.01 level.*

Table 14: Correlation of each simulator-derived continuous dependent variable with each "motivation for participation" measure

Simulator variable	Event	Free movie tickets				Use of simulator				Interest in road safety research				Interest in scientific research			
		Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control
Mean speed (km/hr)	**Total drive**	.017	.026	.046	-.105	.187	.117	.175	.459*	.310	.095	.060	.057	.231	.136	-.074	.118
	Traffic 1	-.283	.228	.147	.052	.258	.091	.273	.405	.236	.037	-.011	-.042	.257	.042	-.058	-.108
	Traffic 2	.251	.060	.137	-.309	-.083	.169	.290	.214	-.088	-.062	-.128	.100	-.045	.075	.061	.022
	Traffic 3	.095	.038	.184	-.306	.382	.148	.278	.528**	.181	.188	-.048	.034	-.021	.149	-.109	.090
	Traffic all	.040	.123	.184	-.220	.223	.146	.322	.458*	.130	.058	-.070	.036	.079	.094	-.043	.001
	Traffic 1 and 3	-.117	.144	.172	-.133	.382	.122	.284	.498*	.251	.112	-.031	-.005	.146	.095	-.086	-.010
	Cross traffic 1	.193	.274	-.024	-.131	.230	-.012	.325	.453	.028	.091	-.030	-.047	-.090	.083	-.190	.034
	Cross traffic 2	.338	.135	.291	-.016	-.031	.049	.040	.227	.347	-.021	-.268	.022	.168	.114	-.376	.053
Mean speed (km/hr)	**Cross traffic all**	.280	.206	.155	-.085	.122	.021	.199	.375	.186	.032	-.169	-.018	.028	.103	-.317	.045
	Pedestrian	.114	.156	-.088	.047	.210	.208	.269	.380	-.186	-.086	-.023	.117	-.56**	-.184	.025	.233

Simulator variable	Event	Free movie tickets				Use of simulator				Interest in road safety research				Interest in scientific research			
		Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control	Ignore	Attend	No instruct	Control
Deceleration (m/s)	**Pedestrian *(a)***	-.043	-.256	.132	-.011	.061	.296	-.093	.304	-.405	-.089	.106	.048	-.402	-.170	.203	.107
	Pedestrian *(b)*	.034	-.005	.177	-.271	-.017	.092	.027	.238	-.354	-.065	.091	.041	-.509	-.254	.064	.303
Mean lateral deviation (metres)	**Total drive**	.322	.201	.400	.307	-.340	-.254	-.299	-.206	-.187	-.395	-.357	-.185	-.304	-.376	-.427*	-.229
	Final block	.427*	.213	.283	.389	-.417*	-.366	-.260	-.345	-.069	-.273	-.289	-.207	-.122	-.242	-.284	-.267
Mean curvature error (1/m)	**Total drive**	.022	-.154	-.099	.217	-.078	.007	-.410	.141	-.055	-.194	.391	-.163	-.002	-.149	.213	-.020
Mean road heading error (radians)	**Total drive**	-.139	.357	.209	-.233	.239	.144	.109	.301	-.157	.109	-.164	-.080	-.173	-.280	-.271	-.116
SD acceleration (g's)	**Total drive**	.341	.239	-.030	.030	-.259	-.199	-.235	-.336	-.096	-.053	-.103	.136	-.104	.036	-.177	.221
SD throttle input (g's/s)	**Total drive**	.453*	.425*	.432*	.377	-.200	-.082	-.254	-.193	-.184	-.162	-.102	.038	-.264	-.256	-.308	.016
SD lateral deviation (metres)	**Total drive**	.325	.214	-.007	.220	-.048	-.084	.143	-.196	-.298	-.131	.108	-.192	-.446*	-.207	-.030	-.205
	Final block	.289	.441*	.230	.303	-.022	-.345	-.279	-.199	-.229	-.231	.032	.136	-.337	-.281	-.128	-.260
SD steering wheel rate (deg/sec)	**Total drive**	.118	-.005	-.054	.029	-.368	-.383	.072	-.182	-.268	.016	.036	.021	-.252	.193	.219	.250
SD curvature error (1/m)	**Total drive**	.088	-.102	.021	.177	-.320	-.307	-.390	-.333	-.258	-.049	.094	-.155	-.141	.160	.163	.124
SD road heading error (radians)	**Total drive**	-.214	.315	.154	-.062	.450*	.074	.102	.422*	.144	.048	-.096	-.161	.052	-.250	-.325	-.117
Speed exceedances	**Total drive**	-.032	-.028	.109	.035	-.074	-.068	-.139	.070	.078	.170	.054	-.057	.034	.209	-.074	-.021

**Significant at .05 level.*
***Significant at.01 level.*

Analysis of continuous simulator-derived dependent variables, with inclusion of relevant covariate

"Corresponding" practice drive measures were considered relevant for a particular dependent variable only if they correlated with the dependent variable in either, or both, of the conditions involved in a particular comparison (see Table 15).

All but one of the significant differences between performance in the "instructed to attend" and control conditions were preserved when corresponding practice drive variables were employed as covariates. In addition, 4 further comparisons became significant. In the "instructed to attend" drivers had a lower mean speed approaching the first set of traffic lights (M=61.70, s.d.=15.54; compared to the control condition M=66.65, s.d.=9.96) and approaching the pedestrian (M=11.48, s.d.=5.04; compared to the control condition M=12.57, s.d.=3.51). Scores in the "instructed to attend condition" were also lower for mean road heading error (M=12.36, s.d.=0.70; compared to the control condition M=12.54, s.d.=0.50) and variability in acceleration (M=0.119, s.d.=0.03; compared to the control condition M=0.120, s.d.=0.02). One previously significant effect was no longer significant (mean lateral position during the curvy road section).

Table 15: Planned contrast analyses repeated using corresponding practice drive measures as covariates for all simulator-derived continuous dependent variables showing a significant correlation with the practice drive measure in either condition involved in the comparison

Simulator variable	**Event**	**Planned contrast analyses**					
		Ignore vs. control		**Attend vs. control**		**No instruction vs. control**	
		F	***p***	***F***	***p***	***F***	***p***
Mean speed (km/hr)	**Total drive**	0.89	.354	7.00	.014*	0.39	.536
	Traffic 1	1.48	.235	6.34	.019*	3.46	.075
	Traffic 2	N/A	N/A	N/A	N/A	N/A	N/A
	Traffic 3	0.04	.843	3.33	.080	3.72	.065
	Traffic 1 and 3	0.61	.442	6.36	.018*	5.30	.030*
	Cross traffic 1	2.29	.143	0.14	.709	1.72	.202
	Cross traffic 2	N/A	N/A	4.15	.052	1.79	.192
	Cross traffic all	2.25	.146	2.19	.152	0.09	.773
	Pedestrian	1.13	.298	8.21	.008*	1.48	.236
Deceleration (m/s)	**Pedestrian (a)**	N/A	N/A	N/A	N/A	N/A	N/A
	Pedestrian (b)	N/A	N/A	N/A	N/A	N/A	N/A
Mean lateral position (metres)	**Total drive**	0.67	.420	0.41	.527	0.46	.502
	Final block	1.82	.190	0.78	.390	1.39	.249

Simulator variable	Event	Planned contrast analyses					
		Ignore vs. control		Attend vs. control		No instruction vs. control	
Mean curvature error (1/m)	**Total drive**	2.26	.145	0.73	.402	0.76	.391
Mean road heading error (radians)	**Total drive**	0.09	.765	14.64	.001*	0.38	.546
SD acceleration (g's)	**Total drive**	0.41	.529	4.80	.038*	0.07	.801
SD throttle input (g's/s)	**Total drive**	0.33	.572	0.30	.592	0.001	.972
SD lateral position (metres)	**Total drive**	N/A	N/A	N/A	N/A	N/A	N/A
	Final block	N/A	N/A	N/A	N/A	N/A	N/A
SD steering wheel rate (deg/sec)	**Final block**	2.28	.144	N/A	N/A	0.36	.555
SD curvature error (1/m)	**Total drive**	3.68	.067	0.10	.758	8.04	.009*
SD road heading error (radians)	**Total drive**	2.07	.163	N/A	N/A	N/A	N/A
Speed exceedance	**Total drive**	0.84	.367	0.27	.611	0.08	.780

**Significant at .05 level.*
***Significant at.01 level.*
N/A: Analysis not performed because corresponding practice drive measure was not related to the dependent variable in either of the conditions involved in the comparison

The use of corresponding practice drive measures as covariates in the comparison between the "no instruction" and control conditions introduced 2 significant effects. Speed approaching the first and third set of traffic lights *combined* was lower in the "no instruction" condition (M=64.90, s.d.=10.96; compared to the control condition M=66.09, s.d.=9.00). Variability in curvature error was higher in the "no instruction" condition (M=8.00^{-4}, s.d.=3.24^{-4}; compared to the control condition M=7.67^{-4}, s.d.= 1.43^{-4}).

The pattern of significant results was unchanged by use of practice drive measures as covariates in the comparison between the "instructed to ignore" and control conditions.

Primary analysis of dichotomous simulator-derived dependent variables

The planned analysis described in the Statistical Analysis section was conducted for all dichotomous simulator-derived dependent variables [see Table 16].

Table 16: Proportion of sample running lights or colliding with vehicles or pedestrians

Simulator variable	Event	Proportions of total events				Planned contrast analyses							
		Ignore	Attend	No instruction	Control	Ignore vs. control		Attend vs. control			No instruction vs. control		
		%	%	%	%	*Chi-square*	*p*	*Chi-square*	*df*	*p*	*Chi-square*	*df*	*p*
Traffic lights ran	**Traffic 1**	35.7	25.0	35.7	17.9	2.28	.131	0.42	56	.515	2.28	56	.131
	Traffic 2	28.6	53.6	46.4	32.1	0.08	.771	2.63	56	.105	1.20	56	.274
	Traffic 3	75.0	78.6	85.0	82.1	0.42	.515	0.11	56	.737	0.13	56	.716
	Traffic 1 and 3	55.4	51.8	60.7	50.0	0.32	.570	0.04	112	.850	1.30	112	.254
Collisions with vehicles at cross intersection	**Cross traffic 1**	3.6	0.0	0.0	0.0	1.02	.313	*NA*	56	*NA*	*NA*	56	*NA*
	Cross traffic 2	0.0	0.0	0.0	0.0	*NA*	*NA*	*NA*	56	*NA*	*NA*	56	*NA*
	Cross traffic all	1.8	0.0	0.0	0.0	1.01	.314	*NA*	56	*NA*	*NA*	56	*NA*
Collisions with pedestrians	**Total drive**	7.1	0.0	0.0	3.6	2.07	.150	*NA*	56	*NA*	*NA*	56	*NA*

Drivers were also no more likely to go through a red light in any of the audiovisual conditions than in the control condition for the first, second, or third set of traffic lights, or for the first and third sets of traffic lights combined. For the first and second set of traffic lights, and for the first and third sets of traffic lights combined, drivers tended to be more likely to run the red in the attend than in the control condition, although the difference did not approach significance.

Primary analysis of questionnaire-measured dependent variables

The mean perceived distraction level for the audiovisual display was 2.57 (*SD* = 0.79), and the mean impairment level was 2.68 (*SD* = 0.90). The vast majority of participants (96.4%) rated the visual materials as at least “a little” distracting, with only 7.1% rating them as “much” or “very much” distracting. Similarly, 96.4% of participants reported that the visual materials impaired their driving at least “a little”, and 17.9% of participants reported that the visual materials impaired their driving “much” or “very much”.

Aim 3-Experiment 2

Primary analysis of continuous simulator-derived dependent variables

The planned analysis described in the Statistical Analysis section was conducted for all continuous simulator-derived dependent variables [see Table 17].

Table 17: Means, standard deviations, and planned contrast analyses for all simulator-derived continuous variables.

Simulator variable	**Event**	**Means and standards deviations**						**Planned contrast analyses**					
		Audiovisual		**Radio**		**Control**		**Audiovisual vs. control**			**Radio vs. control**		
		Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***	***F***	***df***	***P***	***F***	***df***	***p***
Mean speed (km/hr)	**Total drive**	69.42	7.67	69.33	8.72	68.71	9.07	0.23	26	.637	0.18	26	.676
	Traffic 1	70.43	12.36	69.41	13.39	71.78	15.26	0.25	26	.619	0.63	26	.436
	Traffic 2	50.50	11.16	52.40	15.16	49.62	12.56	0.19	26	.670	1.22	26	.280
	Traffic all	60.46	10.08	60.91	13.09	60.70	12.85	0.04	26	.841	0.02	26	.887
	Cross traffic 1	45.78	9.22	46.95	11.99	45.04	10.42	0.37	26	.548	1.75	26	.197
	Cross traffic 2	33.95	11.84	32.57	11.41	33.62	9.95	0.10	25	.752	0.60	25	.447
	Cross traffic all	40.02	8.24	39.46	11.04	39.23	9.63	0.52	25	.479	0.05	25	.834
	Pedestrian	64.66	23.52	59.70	30.18	49.91	30.88	6.01	26	.021*	1.45	26	.239
Deceleration (m/s)	**Pedestrian**	-2.52	2.38	-1.75	2.15	-2.12	2.16	0.28	26	.604	0.55	26	.465
Mean lateral position (metres)	**Total drive**	-1.65	0.50	-1.72	0.76	-1.80	0.25	1.94	26	.176	0.38	26	.545
	Final block	-2.10	0.22	-2.14	0.30	-2.05	0.22	0.85	26	.365	3.60	26	.069
SD lateral position (metres)	**Total drive**	0.66	0.35	0.63	0.31	0.67	0.31	0.00	26	.931	0.32	26	.578
	Final block	0.35	0.13	0.34	0.10	0.34	0.10	0.22	26	.647	0.00	26	.936
Speed exceedances	**Total drive**	5.04	2.19	4.70	2.09	4.63	2.45	0.97	26	.335	0.02	26	.877

**Significant at .05 level*
***Significant at .01 level*

Drivers approached the pedestrian in the audiovisual condition significantly faster than in the control condition (see Figure 8). No further significant effects of sound were observed. A single significant effect could be predicted by chance.

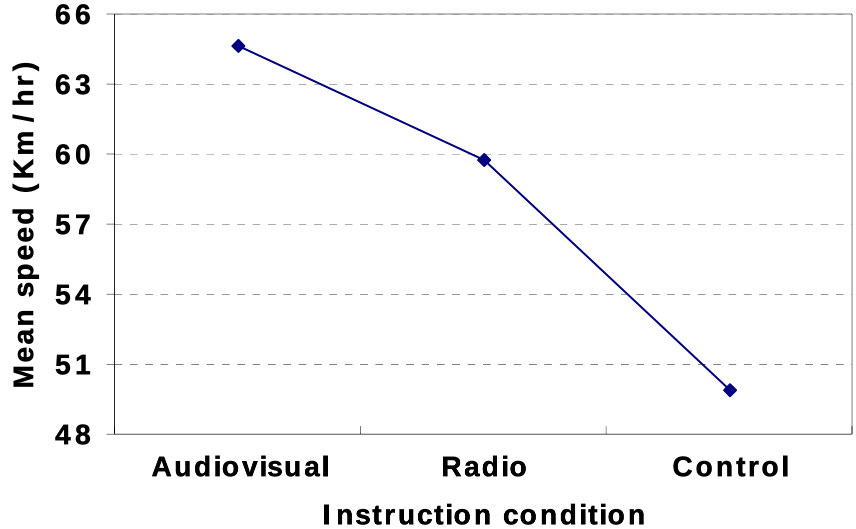

Figure 8: Mean speed approaching pedestrian

Correlations of each continuous simulator-derived dependent variable with personal characteristics

Pearson product moment correlations of each simulator-derived continuous dependent variable with questionnaire-measured personal characteristics, driving experience, and motivation for involvement were computed within each condition (see Tables 18 to 20).

Table 18: Correlation of each simulator-derived continuous dependent variable with each personal characteristic

Simulator variable	Event	Age in years			Gender (*Male = 0, Female = 1)*			Education			Language		
		Audiovisual	Radio	Control	Audiovisual	Radio	Control	Audiovisual	Radio	Control	Audiovisual	Radio	Control
Mean speed (km/hr)	**Total drive**	.100	-.146	-.195	-.099	.011	-.393	.196	.463*	.198	**-.028**	-.057	.226
	Traffic 1	-.160	.065	-.072	-.070	.063	-.431*	.297	.019	.128	.147	-.068	.184
	Traffic 3	.089	-.049	-.094	-.216	.007	-.215	.126	.126	.258	-.126	-.007	.185
	Traffic all	-.049	.005	-.088	-.162	.036	-.360	.251	.083	.202	.020	-.039	.200
	Cross traffic 1	.042	-.043	.022	-.110	.131	-.096	.110	.426	.080	.158	.117	.241
	Cross traffic 2	.077	.024	-.143	.173	-.231	-.159	.173	.322	.166	.243	.154	.280
	Cross traffic all	.031	-.011	-.064	-.132	-.049	-.136	.146	.401*	.132	.223	.145	.280
	Pedestrian	.158	-.254	.078	.151	.029	-.579**	.200	.279	-.096	.081	-.126	.073
Deceleration (m/s)	**Pedestrian**	.101	.214	-.089	.149	.312	-.075	-.066	-.280	.108	-.069	-.064	.070
Mean lateral position (metres)	**Total drive**	-.275	-.171	-.344	-.385*	.109	.048	.139	-.481*	.072	.057	-.157	-.193
	Final block	-.166	-.152	-.471	-.427	-.132	.052	.317	-.037	.174	-.166	-.156	.076
SD lateral position (metres)	**Total drive**	-.328	-.322	.041	-.204	-.039	.167	.111	-.137	-.232	.075	-.038	-.214
	Final block	.222	.310	.188	-.074	.195	.335	-.390	.163	-.079	-.261	-.134	-.132
Speed exceedances	**Total drive**	-.374	-.407*	-.350	-.366	-.020	-.262	.006	.446*	.173	.276	.271	.152

**Significant at .05 level.*

Table 19: Correlation of each simulator-derived continuous dependent variable with each driving ability measure

Simulator variable	Event	Years since Learner's obtained			Number of hours spent driving per week		
		Audiovisual	Radio	Control	Audiovisual	Radio	Control
Mean speed (km/hr)	**Total drive**	.107	-.192	-.221	-.018	-.075	.076
	Traffic 1	-.192	.148	.047	.131	.003	-.150
	Traffic 3	.108	-.013	-.114	-.248	.082	-.110
	Traffic all	-.058	.068	-.084	-.057	.049	-.143
	Cross traffic 1	.055	-.078	.048	.119	.207	.237
	Cross traffic 2	.069	.027	-.107	-.039	-.071	.115
	Cross traffic all	.033	-.029	-.030	.053	.077	.191
	Pedestrian	.156	-.256	.154	.110	.234	.061
Deceleration (m/s)	**Pedestrian**	.117	.165	-.159	-.016	-.127	-.050
Mean lateral position (metres)	**Total drive**	-.265	.003	-.260	.056	.140	.062
	Final block	-.150	-.124	-.467	-.141	-.049	.185
SD lateral position (metres)	**Total drive**	-.370	-.211	.135	.133	-.031	.148
	Final block	.271	.218	.218	.175	.271	.222
Speed exceedances	**Total block**	.173	.410	.334	-.348	-.426	-.365

**Significant at .05 level.*

Table 20: Correlation of each simulator-derived continuous dependent variable with each motivation for participation measure

Simulator variable	Event	Free movie tickets			Use of driving simulator			Interest in road safety research			Interest in scientific research		
		Audiovisual	**Radio**	**Control**	**Audiovisual**	**Radio**	**Control**	**Audiovisual**	**Radio**	**Control**	**Audiovisual**	**Radio**	**Control**
Mean speed (km/hr)	**Total drive**	-.162	-.296	-.021	-.008	.208	-.019	.072	.207	-.078	-.166	-.040	-.329
	Traffic 1	-.004	-.307	-.200	.064	-.024	-.042	.083	-.149	-.068	-.099	-.234	-.300
	Traffic 3	-.319	-.225	-.310	.073	-.128	.041	-.004	-.082	.007	-.197	-.263	-.300
	Traffic all	-.179	-.287	-.270	.079	-.086	-.005	.048	-.124	-.037	-.169	-.272	-.322
	Cross traffic 1	-.083	-.119	-.143	.077	.134	-.032	.064	.299	.050	-.122	.011	-.202
	Cross traffic 2	-.226	-.309	-.026	.158	.224	.266	.108	.185	.119	-.188	-.116	-.112
	Cross traffic all	-.163	-.225	-.092	.125	.190	.124	.092	.261	.090	-.166	-.054	-.170
	Pedestrian	.097	-.160	-.049	.082	.323	.012	.098	.166	-.211	-.072	.204	-.345
Deceleration (m/s)	**Pedestrian**	.084	.239	-.153	-.215	.018	.251	-.241	.064	.118	-.326	.134	.005
Mean lateral position (metres)	**Total drive**	.152	.054	-.103	.134	.015	-.119	.022	-.327	-.059	-.092	.026	.118
	Final block	.269	.063	.029	.083	.054	-.166	.057	-.268	-.109	.085	.017	.252
SD lateral position (metres)	**Total drive**	-.258	.121	.010	-.047	.212	.113	.250	.134	.267	.125	.063	.213
	Final block	.095	-.052	.143	.127	.210	-.059	-.216	.483*	.173	.108	.443*	.184
Speed exceedances	**Total block**	-.220	-.023	-.109	-.255	.329	-.288	-.205	.179	-.148	-.288	-.009	-.252

**Significant at .05 level.*

Primary analysis of dichotomous simulator-derived dependent variables

The planned analysis described in the Statistical Analysis section was conducted for all dichotomous simulator-derived dependent variables [see Table 21].

Table 21: Proportion of sample running lights or colliding with or vehicles pedestrians

Simulator variable	Event	Proportions of total events			Planned Contrast analyses					
		Audiovisual	Radio	Control	Audiovisual vs. control			Radio vs. control		
		%	%	%	*Chi-square*	*df*	*p*	*Chi-square*	*df*	*p*
Traffic lights ran	**Total drive**	39.1	48.4	41.4	0.10	174	.757	0.92	180	.345
Collisions with vehicles at cross intersection	**Total drive**	3.4	11.3	0.0	2.04	116	.154	6.95	120	.008**
Collisions with pedestrians	**Total drive**	34.5	20.7	31.0	0.08	58	.780	0.81	58	.368

**Significant at .05 level.*
***Significant at.01 level.*

Drivers were also no more likely to go through a red light in either sound condition than in the control condition. Drivers were more likely to collide with a vehicle at an intersection in the radio than in the control condition. No further effect of sound on collisions was observed.

Primary analysis of questionnaire-measured dependent variables

The mean perceived distraction level for the audio materials from the audiovisual display was 2.12 (*SD* = 0.99), and the mean perceived impairment level was 1.92 (*SD* = 1.06). For the radio program, The mean perceived distraction level 2.11 (*SD* = 1.09), and mean perceived impairment level was 1.93(*SD* = 0.10).

66.6% of participants rated the audio materials as at least “a little” distracting, with only 7.4% rating the materials as “much” or “very much” distracting. 51.9% of participants reported that the audio materials impaired their driving at least “a little”, and 7.4% of participants reported that the materials impaired their driving “much” or “very much”. 11.1% of participants did not notice the audio materials.

For the radio sound, 66.6% of participants reported that they were distracted at least “a little” and 11.1% reported that they were “much” or “very much” distracted. 59.3% of participants reported that the radio impaired their driving at least “a little”. and 22.2% of participants reported that their driving was “much” or “very much” impaired.

Conclusions and recommendations

The findings of the present study suggest that audiovisual display units that are visible from another vehicle are likely to distract drivers and impair their driving performance.

Of the 26.2% of the sample that reported that they had seen an audiovisual display unit in another vehicle (31.3% on the dashboard), 80% reported that they had paid at least “a little” attention to the last unit they had seen while driving, with 40% reporting that they had paid “much” or “very much” attention (mean= 2.8 on a scale where 3= “some”). The corresponding figures for passengers were slightly higher.

In the simulator, drivers:

1) had a lower mean speed over the entire drive and approaching traffic lights;
2) had a lower mean speed approaching pedestrians (with statistical control for practice drive performance);
3) decelerated more slowly when confronted by a pedestrian;
4) kept a mean lane position on a curvy section of road that was further to the left of centre (although not with statistical control for practice drive performance);
5) had lower mean road heading error (with statistical control for practice drive performance);
6) had lower variability in acceleration (with statistical control for practice drive performance); and
7) kept a more variable lane position on a curvy section of road;

when they were instructed to pay attention to the visual materials from an audiovisual display unit positioned as though it were in a vehicle in a neighbouring lane (compared to a control condition during which no materials were presented). Whilst no differences were observed in the number of red lights run, there was a nonsignificant trend for this to be more likely in the “instructed to attend” than in the control condition.

The finding of lower mean speed is consistent with studies of driving impairment associated with the use of mobile telephones (Alm & Nilsson, 1994; Haigney et al., 2000) or navigation systems (Dingus et al., 1995). Reduced speed can be interpreted in terms of compensation reflecting an awareness of impairment (see Srinivasan and Jovanis, 1997). Whilst this may appear to imply “safer” driving, compensation may not be sufficient. Further, driving at speed which is different to that of surrounding traffic may be dangerous.

Reduced deceleration in response to a pedestrian appearing suggests reduced responsivity to unexpected hazards, and so greater crash risk. Lamble et al. (1999) observed slower reaction times (tested as brake latencies) in drivers using mobile phones (compared to drivers not using mobile phones; see also Alm and Nilsson, 1994; Consiglio et al., 2003).

The risk of an off-road crash may be increased by driving too far to the left of the lane, and by the reduced vehicle control that is suggested by increased variability in lane-position. Decreased lane-keeping performance is also a common finding in studies of driving impairment associated with use of mobile telephones (Haque et al., 2002; Jeness et al, 2002; Reed & Green, 1999; Strayer and Johnston, 2001) or navigation systems (Biever, 2000).

No differences from the control condition were observed when drivers were instructed to ignore the materials. Two significant differences from the control condition were observed when drivers received no instruction, but only when practice drive performance was statistically controlled. Of course, the situation most like the real world is the “no instruction” condition. The pattern of results in the “no instruction” condition was most similar to that of the “instructed to ignore” condition, and indeed most participants reported that they assumed that they should ignore the materials in the “no instruction” condition. However, given that participants report attending to audiovisual displays in other cars in the real world, it is their performance in the “instructed to attend” to condition that is likely to give the best indication of their real-world driving.

The use of practice drive performance as a covariate in analyses served to strengthen the pattern of findings by reducing unnecessary variance.

It might be argued that the PC screen employed to display audiovisual materials in the present study was larger than the audiovisual display units currently available in vehicles (14” vs a maximum of approximately 8”), and so is more likely to cause impairment. However, while a larger screen may be more likely to attract attention, participants’ self-reports indicate that they *do* attend to the smaller screens that currently available. Once attention has been attracted, the *smaller* screens may produce greater impairment because of the greater cognitive capacity required to make out the materials being screened. Thus, if anything, our results may underestimate the impairment produced by attending to the smaller audiovisual display units that are currently available in vehicles.

The notion that currently available screens impair driving is also suggested by participants’ reports of their on-road experiences. 96.4% of the sample reported that they were at least “a little” distracted by the visual materials from an audiovisual display unit whilst they were driving, with 7.1% reporting that they were “much” or “very much” distracted (mean= 2.57 on a scale where 3= “some”). 96.4% of the sample reported that their driving was at least “a little” impaired, and 17.9% reported being “much” or “very much” impaired (mean= 2.68 on a scale where 3= “some”).

Navigational systems in other vehicles may also be problematic. Of the 21.3% of the sample that reported that they had seen an audiovisual display unit in another vehicle (75% on the dashboard), 75% reported that they had paid at least “a little” attention to the last unit they had seen, with 25% reporting that they had paid “much” or “very much” attention (mean= 2.5 on a scale where 3= “some”). Impairments may be similar to those occasioned by audiovisual display units.

The findings of the present study suggest a limited effect of the audio materials of and audiovisual program playing in the back of a vehicle, or of radio, on simulated driving performance. Compared to the control condition, drivers hearing the audio materials from an audiovisual program approached a pedestrian significantly faster, and drivers hearing the radio were more likely to collide with cross-traffic. However, these significant effects are likely to have occurred by chance (given the number of tests conducted). Nonetheless, some respondents reported that they were distracted, and that their driving was impaired, by audio materials.

The samples employed in the present study were relatively small (due to lack of comparable data upon which to base statistical power calculations, and budgetary restrictions), however this is unlikely to have changed the research conclusions. In Experiment 1, the statistical power was sufficient for 5 significant differences to be observed between the “attend” and control conditions. A further 4 differences between these conditions approached significance (all ps<.061), and may be significant in a larger sample. Two of these, for speed approaching Traffic light 1 and speed approaching Traffic light 3, contributed to the significant difference observed for speed approaching Traffic lights 1 and 3 (together). The remaining 2 were also consistent with the pattern of impairment in the “attend” (compared to the control) condition. Only one comparison of the other conditions (“ignore” and “no instruction”) with the control condition approached significance (p=.091, all other ps>0.114). Thus, the pattern of results of Experiment 1 is unlikely to change given a larger sample. In Experiment 2, one significant difference was observed between audiovisual sounds and control conditions, one near-significant difference was observed between radio and control conditions (p=.069), and no other comparisons approached significant (all ps>.176). Thus, the pattern of results for Experiment 2 is also unlikely to change given a larger sample.

Overall, results suggest a visual impairment, but a cognitive impairment cannot be ruled out. The reduction in driving performance due to the visual materials, but not due to the audio materials, suggests that visual impairment is important. Nonetheless, a cognitive impairment may also contribute to the observed effects of visual material on driver performance.

The relevant authorities should consider amending the Australian Road Rules to explicitly require that audiovisual displays not be visible to other drivers. Clause (b) of Australian Road Rule 299 would have the same effect when taken with the results of the present study, however the explicit statement is likely to be clearer to road users, to industry, and to regulators. Audiovisual *displays* might be rendered invisible to drivers (whilst the audiovisual display unit remains visible) through appropriate screen design.

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Appendix A

UNSW

THE UNIVERSITY OF NEW SOUTH WALES

RESEARCH PARTICIPANTS REQUIRED

Licensed drivers are needed as research participants for a project examining the influence of in-car audio-visual displays on simulated driving. The study will be conducted at the University of New South Wales in a driving simulator which consists of a full car body with real steering, braking and acceleration systems; large screens that display the road environment; and auditory feedback.

Participants will complete some drives in the simulator, and a brief questionnaire. The session will take approximately 1 hour. Participants will then receive 2 free movie tickets to compensate for their time and travel expenses.

If you are interested in this study, or would like more information, please contact Tim Chamberlain on 0401398280.

NSW INJURY RISK MANAGEMENT RESEARCH CENTRE

CRICOS PROVIDER CODE NO. 00098G

Appendix B

THE UNIVERSITY OF
NEW SOUTH WALES

NSW Injury Risk Management Research Centre
The University of New South Wales

The Effects of In-Car Audiovisual Displays on Simulated Driving

Part I. Driving Simulator

1. While you were in the simulator, there was a movie playing during three of the drives. Did you recognise this movie as one you had seen before? *(Please tick one response only below)*

☐ Yes

☐ No

2. Please rate the extent to which the movie was distracting overall. *(Please circle the appropriate response below)*

1	2	3	4	5
Not at all	A little	Some	Much	Very much

3. Please rate the extent to which the movie impaired your driving performance overall. *(Please circle the appropriate response below)*

1	2	3	4	5
Not at all	A little	Some	Much	Very much

Part II. In-Vehicle Audiovisual Screens

N.B. This section asks about your experiences travelling on actual roads - not your experiences in the driving simulator.

1. Have you ever noticed an in-vehicle TV/video/DVD or navigation screen in another vehicle (not the vehicle you were in) while you were on the road? *(Please tick as many options as relevant)*

Explanation: An in-vehicle audiovisual screen refers to a television, video, DVD or navigation system etc designed for a vehicle.

☐ TV/video/DVD

☐ Navigation system

☐ Other
(Specify)____

☐ Never noticed *(Please go to question 8 below)*

2. Think of the last time you were on the road and you noticed one of these screens in another vehicle. Approximately, how long ago was this? *(Please tick one response only below)*

☐ Less than 1 day
☐ Between 1 day and 1 week
☐ Between 1 and 2 weeks
☐ Between 2 and 3 weeks
☐ Between 3 and 4 weeks
☐ More than 4 weeks

3. Was the screen a… *(Please tick one response only below)*

☐ TV/video/DVD?

☐ Navigation system?

☐ Other?
(Specify)____

4. Can you remember where the screen was located in this vehicle? *(Please tick one response only below)*

☐ Back of the front seats

☐ Suspended from the roof in the front
☐ Suspended from the roof in the back
☐ On the dashboard
☐ Other (specify)__________________________
☐ Do not remember

5. To what extent did you pay attention to the screen? *(Please circle the appropriate response below)*

1	2	3	4	5
Not at all	A little	Some	Much	Very much

6. Do you remember anything about the image on the screen (e.g., whether it was a movie, TV show, comedy, drama, name of program etc)**?** *(Please tick one response only below)*

☐ Yes
(Specify) ____

☐ No

7. When you saw the screen, were you driving or were you a passenger? *(Please tick one response only below)*

Driving
☐ Passenger

8. Have you ever owned a vehicle (including your current vehicle) in which a TV/video/DVD or navigation system was installed? *(Please tick one response only below)*

☐ TV/video/DVD
☐ Navigation system

☐ Other
(Specify)____

- [ ] Never owned *(Please go to Part III below)*

9. Where in your vehicle was the screen located? *(Please tick one response only below)*

- [ ] Back of the front seats
- [ ] Suspended from the roof in the front
- [ ] Suspended from the roof in the back
- [ ] On the dashboard
- [ ] Other (specify)__________________________
- [ ] Do not remember

10. While driving with the TV/video/DVD or navigation system turned on, to what extent would you pay attention to the sound or image? *(Please circle the appropriate response below)*

1	2	3	4	5
Not at all	A little	Some	Much	Very much

Part III. Personal Driving Information

1. On average, how many hours would you spend driving each week?

________hours

2. How long has it been in years since you received your Learner Driver License?

________years

3. What type of driver's license do you hold? *(Please tick one response only below)*

- Learner’s license
- Red P-plates
- Green P-plates
- Full license
- License disqualified

Part IV. Demographic Information

1. What is your date of birth? ________________

2. Are you male or female? *(Please tick one response only below)*

Male   Female

3. What is the highest level of education you have achieved? *(Please tick one response only below)*

School Certificate
HSC
Tertiary (e.g., university, TAFE)

4. What is the main language spoken at home? ________________

5. What is your postcode? _________________

Thank you very much for your participation!

Appendix C

Please rate the extent to which you agree with each of the following reasons for why you decided to participate in our study, by circling one of the 7 response options below.

Strongly Disagree — Neutral — Strongly Agree
1 2 3 4 5 6 7

a) because you get free movie tickets.

Strongly Disagree — Neutral — Strongly Agree
1 2 3 4 5 6 7

b) because you get to use the driving simulator.

Strongly Disagree — Neutral — Strongly Agree
1 2 3 4 5 6 7

c) because you are interested in scientific research.

Strongly Disagree — Neutral — Strongly Agree
1 2 3 4 5 6 7

d) because you are interested in road safety research.

e) Other (specify)

____

Please indicate how you were able to participate in our study on a weekday, by ticking one of the response options below only.

- ❑ **You do part-time work**
- ❑ **You do casual work**
- ❑ **You do shift work**
- ❑ **You did the study on your lunch break**
- ❑ **You are on a work holiday**
- ❑ **You are on a student holiday**
- ❑ **You are unemployed**
- ❑ **You are retired**
- ❑ **Other (Specify)** ______________________________

Thank you for your time!

Appendix D

Quiz 1

1. At the beginning of the scene there is a boy. Is the boy.... *(Please tick one response only below)*

- ☐ Jumping on a trampoline?
- ☐ Riding on a bus?
- ☐ In bed, waking up?

2. Soon after, the boy wakes up and sees a tiny Indigenous American. Where is the tiny Indigenous American standing? *(Please tick one response only below)*

- ☐ On the bedside table
- ☐ On the window sill
- ☐ On his own head

3. After the boy gets up, where does he go carrying a small cardboard box? *(Please tick one response only below)*

- ☐ To put the box in the recycling
- ☐ Down the street
- ☐ Out into the garden

4. When the boy arrives at his destination, he gathers some items. What kind of items are these? *(Please tick one response only below)*

- ☐ Clothes off the line
- ☐ A tray with dirt, some sticks and a cardboard box
- ☐ A bicycle, bike pump and tyres

5. When the boy goes back to his room, there is something wrong with the tiny Indigenous American. What is wrong with him? *(Please tick one response only below)*

- ☐ He has head pains
- ☐ He can't make a fire
- ☐ He has a cut on his leg

Quiz 2

1. At the beginning of the scene there is a tiny Indigenous American. What is he doing? *(Please tick one response only below)*

☐ Sitting on the structure of a hut
☐ Playing ping pong
☐ Dancing around a tiny fire

2. Soon after, a boy arrives home. Where does he run to? *(Please tick one response only below)*

☐ To the kitchen to fix a sandwich
☐ Out into the back garden to talk to the tiny Indigenous American
☐ Upstairs to see the tiny Indigenous American

3. When the boy arrives at his destination, what does he see? *(Please tick one response only below)*

☐ That there is no mayonnaise left
☐ That the tiny Indigenous American has finished building his hut
☐ That there is a small dog in the garden

4. What does the boy then put in a small white cupboard? *(Please tick one response only below)*

☐ Some money
☐ A small figurine
☐ His school bag

5. Soon after, a second tiny Indigenous American comes onto the scene. What happens to him when he sees the boy? *(Please tick one response only below)*

☐ He dies of fright
☐ He falls off the cabinet
☐ He is struck by a giant ice cream

Quiz 3

1. At the beginning of the scene there is a boy asleep in bed. What is happening on his bedroom floor? *(Please tick one response only below)*

☐ A tiny cowboy and an Indigenous American are fighting
☐ A tiny American Indian is dancing around a fire
☐ There is a kitten playing with some string

2. What does the boy do when he wakes up and gets out of bed? *(Please tick one response only below)*

☐ Goes downstairs to have breakfast
☐ Plays with his toys
☐ Breaks up a fight between a tiny cowboy and an Indigenous American

3. Soon after, the scene changes and the boy is at school. What happens? *(Please tick one response only below)*

☐ He slips over and grazes his knee
☐ The tiny Indigenous American shoots arrows at the teacher
☐ The teacher tells the boy and his friend to get to class

4. What is happening in the classroom? *(Please tick one response only below)*

☐ The class is having show and tell
☐ The class is having a chemistry lesson
☐ The children are throwing things at the teacher

5. What is it the boy and his friend seem to be preoccupied with? *(Please tick one response only below)*

☐ A girl at the front of the room
☐ A yellow bum bag
☐ A small white box