AGE AND GENDER DIFFERENCES IN STRESS RESPONSES DURING SIMULATED DRIVING

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A study of group differences in susceptibility to stress during simulated driving is reported. 74 drivers participated, with approximately equal numbers of younger (18-25) and older (55-78) drivers, and of men and women. Stress was manipulated by exposing half the sample to a failure experience; frequent, uncontrollable skids. Following the stress manipulation, drivers' hazard perception, speed and vehicle control were assessed. Subjective state before and after the drive was assessed by questionnaire. It was hypothesized that older and female drivers might show greater subjective distress and performance impairment in the stress condition. Results showed that age was a stronger influence on performance than either gender or stress. Older drivers showed impairments in hazard detection and vehicle control, but appeared to compensate through slower speed. Older drivers and women showed higher levels of distress throughout the study, but these groups did not show any differential sensitivity to the stress manipulation. It is concluded that driver stress as a safety problem largely depends on individual differences, although group differences may be evident in other circumstances.

Driver stress is a significant safety problem (Selzer & Vinokur, 1975). Stress may impair performance through distracting the driver from maintaining safety, or through eliciting potentially dangerous coping strategies such as reacting aggressively to other traffic. The psychology of driver stress rests on two key points. First, driver stress is multi-dimensional. Matthews et al. (1998) distinguished multiple dimensions of vulnerability to driver stress. For example, a dimension labeled Dislike of Driving is associated with unhappiness and anxiety during driving, intrusive, distracting thoughts and a high incidence of self-reported errors. Simulator studies have confirmed that Dislike of Driving is associated with impaired vehicle control and attention, especially under stressful conditions (Matthews, 1997; Matthews et al., 1998). Short-lived states of stress also appear to be multidimensional, and it may be important to distinguish mental fatigue, emotional distress and worry as stress reactions with differing implications for performance (Matthews et al., 1999). The second key observation is that driver stress is controlled by cognitive processes. Anxiety reactions depend on *appraisals* of threats to personal safety and competence, and on *coping* with threats through strategies such as self-criticism and ruminative worry ('emotion-focused' coping). Conversely, task-focused coping through attention to safety-enhancing behaviors may improve performance.

There is little existing research on group differences in response to stressful incidents during driving. Questionnaire data suggest that both age and gender may influence stress vulnerability. Matthews, Desmond, Joyner and Carcary (1997) found that older drivers were lower in Aggression, but age had no effect on Dislike of Driving. Conversely, women were higher in Dislike, but gender was unrelated to Aggression. It is unclear whether these group differences in self-reported stress vulnerability are expressed in driver behavior; e.g. whether women show greater performance deterioration under stress than men. In addition, there may be group differences in stress response associated with variation in cognitive efficiency. As with performance generally, older drivers tend to show deficits in measures of attention during driving (Ball & Owsley, 1991). These deficits become accentuated as the task becomes more demanding (Ponds, Brouwer & Van Wolffelaar, 1998), implying that older drivers may be vulnerable to overload of attentional capacity. Coping with stress often adds to the demands of task performance, as attention is allocated to formulating a behavioral response to the stressor and/or processing internal thoughts and affect. Hence, older drivers may be especially vulnerable to

performance impairment under stress, if they have insufficient attentional capacity to manage both the task and the stressor successfully.

Aims

The study used a driving simulator to test for age and gender differences in subjective and behavioral response to an experimental stress manipulation developed and validated by Matthews (1997; Matthews, Sparkes & Bygrave, 1996). The manipulation exposes drivers to a failure experience; frequent loss of control of the vehicle due to 'ice on the road'. The previous studies showed that the stress manipulation elicits negative affect and cognitions, and impairs performance in high Dislike drivers. Subjective response to stress was assessed by having drivers complete a validated stress state questionnaire (Matthews et al., 1999) before and after the drive. Drivers' appraisal of personal control, and their use of coping strategies during the drive, was also assessed. Following stress induction, several aspects of driver behavior were assessed, including speed, vehicle control and detection of roadside hazards. Task load was varied by comparing performance on straight and curved road sections.

Given that older drivers may have relatively little 'spare capacity' for coping with stress, it was predicted that older drivers would show greater subjective distress following the stress manipulation. Age should also relate to performance decrement, especially in higher task load conditions (driving on curves). Because women report higher Dislike of Driving than men, it was expected that female drivers would show greater distress and poorer performance following stress induction.

Method

Subjects. 74 British drivers participated, of whom 16 were younger males, 18 older males, 22 younger females and 18 older females. Younger drivers were aged 18-25, older drivers 55-78.

Design. A $2 \times 2 \times 2$ between-subjects design was employed, with factors of age, gender and stress exposure. Performance analyses included an additional within-subjects factor of curvature (curve vs. straight). Analyses of subjective stress response included an additional within-subjects factor of time (pre-drive vs. post-drive).

Procedure. Each participant was individually tested on a single occasion, using the University of Dundee driving simulator, a fixed-base low fidelity simulator. Graphics were presented on a 22" monitor, and control is effected via a steering wheel and gas and brake pedals (see Matthews et al., 1996, 1998). On arrival, subjects practiced the simulator tasks, including single-task driving and driving plus hazard detection. The hazard detection task required drivers to press a button set into the wheel in response to pre-designated hazards, i.e. child pedestrians, vehicles parked on the driver's side of the road, vehicles moving towards the roadway on a lateral path and signs with the word 'DANGER'. Drivers were required to ignore designated non-hazards: adult pedestrians, vehicles parked on the other side of the road, vehicles moving away from the roadway and signs with place names. No hazards required evasive maneuvers or change of speed.

After practice, drivers completed the Dundee Stress State Questionnaire (DSSQ: Matthews et al., 1999) which assesses subjective stress reactions related to mood, motivation and cognition. Drivers then performed a simulated drive lasting about 20 minutes. In the first part of the drive, half the sample was exposed to the stress manipulation, in which frequent uncontrollable skids occurred. The remaining subjects were allocated to a control condition, in which driving conditions were normal. In the second part of the drive, drivers engaged in single and dual-task driving, on alternating straight and curved road sections (of radius 76 m), performing the hazard detection task as the second of the dual tasks. The dual-task phase of the drive lasted about 10 minutes. The road driven during this phase comprised 3 straight and 3 curved sections. In total, 24 hazard stimuli and 120 non-hazard stimuli were encountered, in a pseudo-random order.

Finally, drivers completed a post-drive DSSQ to assess their subjective state during the second part of the drive, and a scale assessing perceived control. 55 of the sample also completed the Coping Inventory for Task Stress (CITS: Matthews & Campbell, 1998), which assesses three basic dimensions of coping: task-focus, emotion-focus and avoidance (withdrawal of effort from the task).

Results

Driving performance. Driving performance was assessed with dependent variables of (1) speed and (2) heading error, i.e. the mean deviation between the direction of the vehicle and the direction of the road. Previous studies show that heading error is highly sensitive to various stress and task demand factors (e.g. Matthews et al., 1996). A main effect of curvature was obtained ($F(1,66)=20.4$, $P<.01$) such that speed was slower on curves (25.2 m.p.h) than on straights (26.4). The analysis of effects on speed also showed a significant main effect of age ($F(1,66)=20.4$, $P<.01$), and

a significant age × curve interaction (F(1,66)=5.3, P<.01). Older drivers were slower, especially on curves. Analysis of heading error data showed main effects of both age (F(1,66)=14.1, P<.01)and gender (F(1,66)=4.2, P<.05): heading error was higher in older drivers and in women. The main effect of curvature (F(1,66)=619.2, P<.01) and the age × curve interaction were also significant (F(1,66)=4.7, P<.05). As expected, heading error was higher on curves than straight sections, but the age difference was larger on curves than on straights (see Table 1). Mean heading error was 1.82° in men and 2.09° in women.

Table 1. Driving performance as a function of age and curvature.

	Speed (mph)		Heading error (°)	
Age	Straight	Curve	Straight	Curve
Older	24.6	22.9	1.47	3.02
Younger	28.0	27.4	1.05	2.33

Hazard detection. Three dependent measures were used to assess performance on the hazard detection task: (1) perceptual sensitivity (indexed by A'), (2) mean distance at which correctly-detected hazards were discriminated, and (3) temporal lag to hazard at correct detection, calculated as (distance to hazard)/speed at detection. Curvature affected mean distance only (F(1,66)=35.4, P<.01): hazards were detected at a shorter distance on curves (37.2 m) than on straights (40.2 m). There were significant main effects of age on perceptual sensitivity (F(1,66)=20.4, P<.01) and on temporal lag (F(1,66)=8.9, P<.01). Older drivers showed lower perceptual sensitivity, but detected hazards at a longer temporal lag. There were no effects of gender or stress on the hazard detection measures.

Table 2. Age differences in performance, averaged across gender, curvature and stress condition.

Measure	Older	Younger	Sig.
A`	.93	.99	P<.01
Distance (m)	38.7	38.6	NS
Time lag (s)	4.06	3.41	P<.01
Speed (mph)	24.7	27.7	P<.01
Heading error (°)	2.25	1.66	P<.01

In general, effects of age on performance were stronger than those of either gender or stress. Table 2 summarizes the performance differences between older and younger drivers, averaging data across straights and curves.

Subjective data. The DSSQ was scored so as to assess three stress factors of Distress, Worry and Task Engagement (see Matthews et al., 1999), which were analyzed as dependent measures. Distress refers to negative emotion and perceptions of loss of control, Worry to intrusive, distracting thoughts, and Task Engagement to energy, motivation and concentration. There were main effects of time (i.e. pre- vs. post-task administration) on Task Engagement (F(1,66)=11.8, P<.01), Distress (F(1,66)=16.1, P<.01) and Worry (F(1,66)=14.0, P<.01). Distress increased by .34 SD post-task, Worry decreased (-.28 SD) and Task Engagement also decreased (-.27 SD). As expected, there was a significant stress × time interaction (F(1,66)=11.0, P<.01): distress increased more in the stress condition than in the control condition. There were significant main effects of age on Distress (F(1,66)=11.6, P<.01) and on Task Engagement (F(1,66)=7.2, P<.01): older drivers reported higher levels of both factors. In addition, women were higher in distress than men were (F(1,66)=8.1, P<.01). However, neither age nor sex interacted with the time factor, indicating that they did not affect reactions to the driving task. Age and sex differences were as strong in pre-drive data as they were post-drive. Figure 1 shows effects of age and the stress manipulation on *change* in state, i.e. post-task state – pre-task state. Change scores are expressed as z-scores, standardized against the Matthews et al. (1999) norms.

Effects of independent variables on the four cognitive process variables of perceived control, and task-focused, emotion-focused and avoidance coping were assessed within 2 × 2 × 2 (age × sex × stress) ANOVAs. There were significant main effects of age on perceived control (F(1,70)=8.7, P<.01), task-focused coping (F(1,47)=9.1, P<.01) and avoidance coping (F(1,47)=6.8, P<.05). Older drivers experienced less control but coped through use of more task-focus and less avoidance. The stress manipulation elicited significantly lower control (F(1,70)=23.1, P<.01), and more emotion-focus (F(1,47)=6.6, P<.05). Figure 2 shows age and stress effects. Gender differences were minimal, although there was a significant age × sex interaction on task-focus (F(1,47)=4.3, P<.05): younger women tended to use less task-focus than young men.

Figure 1. Standardized change scores in three dimensions of subjective stress state as a function of age and stress condition (S- = lower stress; S+ = higher stress).

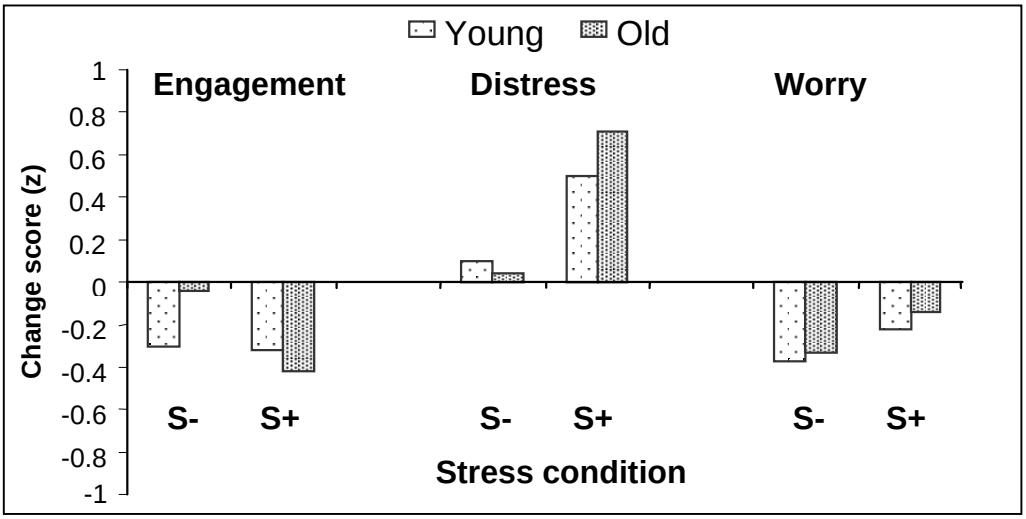
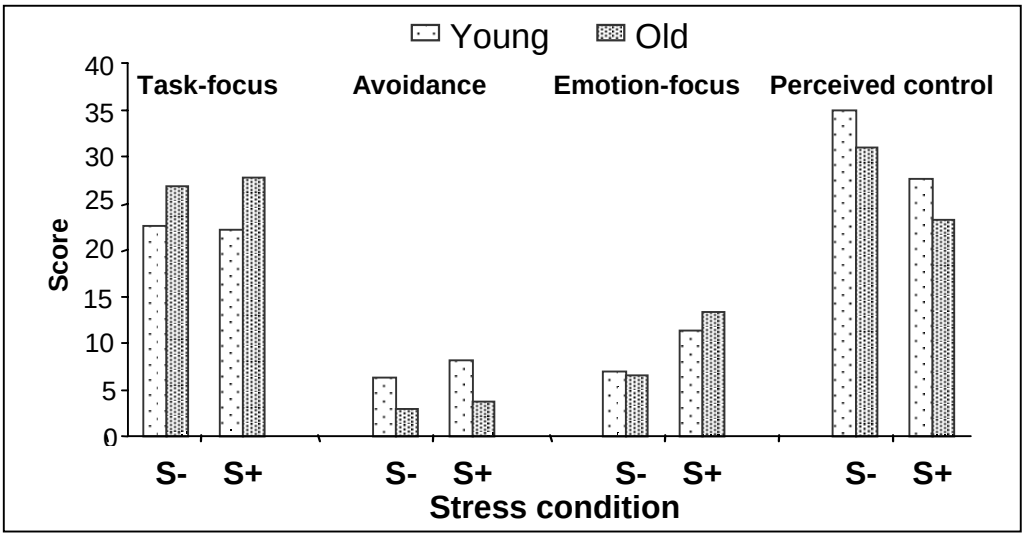


Figure 2. Scores on scales for coping and perceived control as a function of age and stress condition (S- = lower stress; S+ = higher stress).



Discussion

The most striking feature of the data was the set of age differences in performance shown in Tables 1 and 2. As in previous research (Ball & Owsley, 1991), older drivers showed evidence of performance impairment, relative to younger drivers. They showed lower perceptual sensitivity in detecting hazards, and their control of lateral position of the vehicle was poorer, as evidenced by greater heading error. The study provided only weak evidence for an attentional capacity explanation of these findings: curvature moderated the age difference in heading error, but not in hazard detection. Furthermore, the effect on heading error may be a scaling artifact associated with the overall poorer performance of the older drivers. The curve: straight ratio for heading error was actually higher in younger drivers (2.22) than in older drivers (2.05). The data also suggest that older drivers compensated for cognitive deficit by driving more slowly, especially on curves. In some respects older drivers may be safer than younger drivers, in that, because they drive more slowly, they showed longer temporal lags; i.e., they have longer to react to potential hazards. Gender differences in performance were minor, although heading error was higher in women than in men.

As in previous studies (e.g. Matthews et al., 1996), the subjective data confirmed that the stress manipulation was indeed stressful, tending to induce feelings of emotional distress, appraisals of lack of control and the normally maladaptive strategy of emotion-focused coping. As predicted, older and female drivers reported higher levels of subjective distress during the study. However, these group differences were evident in pre-drive data, suggesting that they derived from generalized expectancies about driving, rather than from the drive itself. It is possible also that older and female drivers found the simulator itself aversive.

Age also influenced cognitions of the drive. Although older drivers experienced less perceived control, they also used more task-focused and less avoidant coping strategies than younger drivers. Coping in this way should be adaptive in the driving context. Plausibly, we might suppose that older drivers find driving in demanding conditions somewhat stressful, due to loss of cognitive competence. However, they may also have learnt to compensate for their negative experience of driving though use of adaptive coping, i.e. actively maintaining safety through task focus. This style of coping may reduce, though not eliminate performance deficit.

There were no group differences in either subjective or objective response to the stress manipulation, which did not influence performance. Previous studies (Matthews et al., 1996) showed individual differences in both subjective stress and performance, associated with the Dislike of Driving stress vulnerability factor. Vulnerability to driver stress may be best understood at the level of the individual rather than the group, although group differences may be evident in other circumstances. Possibly, there might be group differences in reactions to other types of stressor. Kosnik, Sekuler and Kline (1990) suggested that older people are sensitive to their own visual deficits, so that older drivers might experience visually-demanding environments such as night driving as particularly stressful.

The data imply that somewhat different safety interventions may be required for older and younger drivers. Older drivers appeared to be prone to failures to detect hazards altogether, demonstrating a need to make road-signs, other traffic and displays internal to the car highly conspicuous. It is unclear whether the heading error deficit would generalize to real driving. If so, active steering and position-monitoring devices that facilitate vehicle control may be especially useful to the elderly. However, human factors researchers may also have something to learn from the behavioral compensation exhibited by older drivers. For example, the more active attitudes towards maintaining safety exhibited by older drivers imply that this group may be less vulnerable than younger drivers to ‘complacency’ in operating automated vehicles. Older drivers may be especially capable of benefiting from automation, without suffering its concurrent drawbacks. Further research might also be directed towards the attitudes and beliefs concerning personal safety and competence which influence speed choice.

Finally, caution is needed in extrapolating from the simulated drive to real-world driving. It is unclear whether the age differences in stress reactions would be reproduced in real settings. In support of the simulator method, individual differences in subjective and objective stress reactions to driving seen in the laboratory appear to generalize to real-world settings (Matthews et al., 1998). Furthermore, the mean levels of stress state variables were comparable to or higher than levels observed in our studies of real driving, implying that simulated drives may present some of the same challenges as real driving.

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