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42 Age- and/or expertise specific modes of coping with mental workload

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Abstract

One crucial problem for designing complex workspaces requiring activities on different levels of priority is to influence the user to apply a suitable strategy for allocating attention. URE has tested different forms of information design (according to the criteria developed by Tullis, 1981) and presentation (with or without cueing) in cars in order to investigate how these variables influence the drivers' allocation behaviour and mental workload. The experiments have been performed in a (video) simulator and in the field with an especially equipped car. Physical (speed and steering behaviour plus a video of the viewing behaviour and the traffic situation) as well as subjective variables (workload questionnaires and video supported critical incident techniques) have been reported. The subjects have been grouped according to age and driving expertise and as a covariate the subjects' optometric data. The data show that overall the subjects give highest priority to the driving task, especially to the safety relevant tasks. However, the reliability of this strategy depends on (i) situational traffic variables, (ii) the design and presentation mode of the information in the secondary task, (iii) the driving expertise, and (iv) the age of the drivers. Furthermore, subjects with severe unilateral visual impairments have been unable to shift the attention from the secondary task to the driving tasks in some critical situations.

In conclusion, instruments assisting, informing, or entertaining the driver in traffic can impair the driving performance if they are not tuned to the traffic situation and the specific information processing skills of the driver. Especially the elderly prefer to allocate their attention autonomously; in contrast, younger

drivers profit from the cueing of novel information with the undesirable side effect that in the case of lacking expertise this can result in a 'command effect'.

Introduction

The classical models of the allocation of attention (e.g. Kahnemann, 1973) assume that every task to be performed needs a certain amount of 'mental energy' and that in the case of more than one task the role of attention consists in allocating this 'mental energy' in the way of a scarce resource. The workload according to this model is equivalent to the amount of this kind of energy required in a specific situation in relation to the total amount available (the competence). The optimal strategy to lower the workload then consists in making the single tasks easier up to automation where no energy is necessary. Navon and Gopher (1979) have specified this model by pointing out that attention is not general but modality specific which implies that even two automated tasks interfere if the same modality has to be used in performing them. In the light of this and other basic results on attention the optimal strategy for relieving mental workload would consist in using many modalities for perceiving signals and executing the respective tasks. One example for the construction of a workplace according to these principles is the push-button design used by Airbus Industries where the change in colour of the light behind the button signals the status of the respective function and the urgency of intervening by pushing the button. While this design makes learning easier and efficiently supports novices, experts quite often regard it as cumbersome and even dangerous, namely in situations where non-standard interventions are necessary. Wehner (1993) has reported that novice navigators make their supervisory and intervening behaviour dependent on warning signals, expert navigators, in contrast, sample permanently the status of all relevant indicators even if no warning signals are given. The advantages of this strategy consists in the possibility to disambiguate situations by means of their history and in the experience of the operator to be 'in control'. In the light of the availability and potential of modern information technologies in cars, it is necessary to assess their influence on different kinds of drivers; in order to evaluate these effects it is not only necessary to gather performance data and to ask for self assessments of workload (the standard measurement procedures for workload assessment), but to develop methods for observation and interview which allow to uncover the strategies of supervisory control (Sheridan, 1992) underlying the performance in a specific situation.

Assistive technology in the car (for an overview see Ian Noy, 1998) can support the driver in regulating, deciding, and planning; especially for the elderly drivers technologies are important which help them to overcome the difficulties due to the decline in sensory-motor performance. However, these assistive systems shift the work characteristic in driving from direct regulation to indirect monitoring, for this reason URE [1] has analysed how the display design and the interaction mode of a simulated planning support system influences (i) driving performance, (ii) division of attention between the (primary) driving task and the (secondary) monitoring task, and (iii) the experienced workload.

Overview of methodolgy

According to the deficit model of ageing and Birren's (1965) complexity hypothesis it is to be expected that especially older drivers might have problems in managing the dual task; for this reason we have compared in a first simulator experiment the driving behaviour of 16 subjects in the range of 25-35 years with that of 16 subjects older than 55 years. In order to check the influence of the visual performance, the vision of all subjects was tested and used as a covariate. In a subsequent field experiment with 12 subjects in the same age range but without visual deficits it has been analysed if the results follow the same pattern as in the simulator experiment with the important addition of registering the traffic violations rated according to severity and safety implications.

The simulator consists of a real limousine with all controls which have to be used according to the projected video traffic scenes.

Results and discussion

In the simulator practically all subjects in all situations gave priority to the (primary) driving task, only three subjects in one situation have been distracted by the (secondary) planning task to such an amount that in real traffic an accident would have happened; analysing the vision data for these subjects reveals that they all had severe impairments in the right eye.

Driving performance (lateral stability) decreased systematically according to the complexity of the traffic situations (see figure 1) the demands of the secondary task (see figure 2), and the age of the drivers (see figure 3).

Furthermore, there is a significant interaction between age and traffic situation, that is, the impairment of the lateral stability increases faster in older drivers if the situations become more complex (see figure 4).

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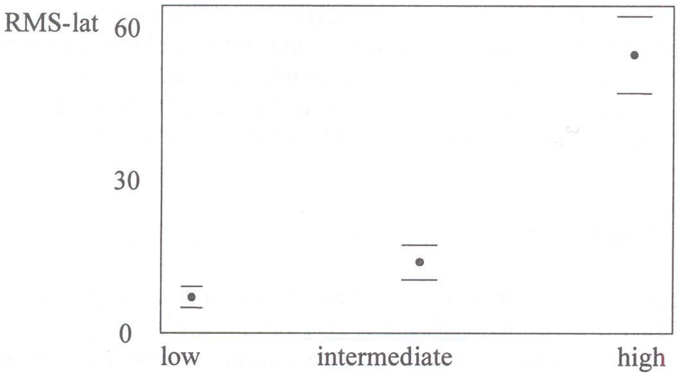

Figure 1 Complexity of the traffic situation

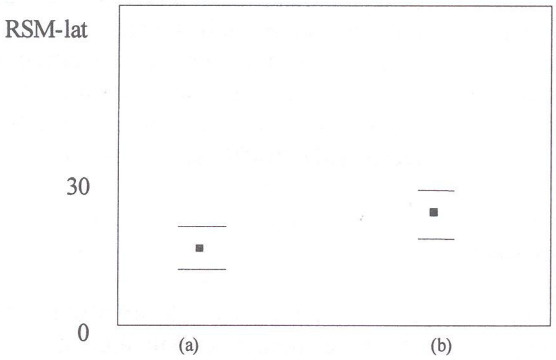

Figure 2 Lateral stability (a) with and (b) without secondary task

Figure 3 Effect of age on lateral stability

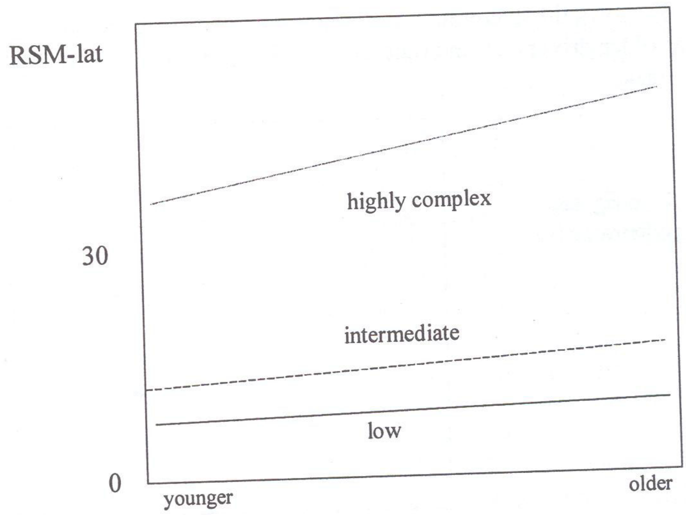

Figure 4 Interaction between age and situational complexity

If one measures the performance in the secondary task (L = (N correct reactions - N mistakes)/ N all reactions) it becomes apparent that the subjects shift their attention to the secondary task according to the demands on driving:

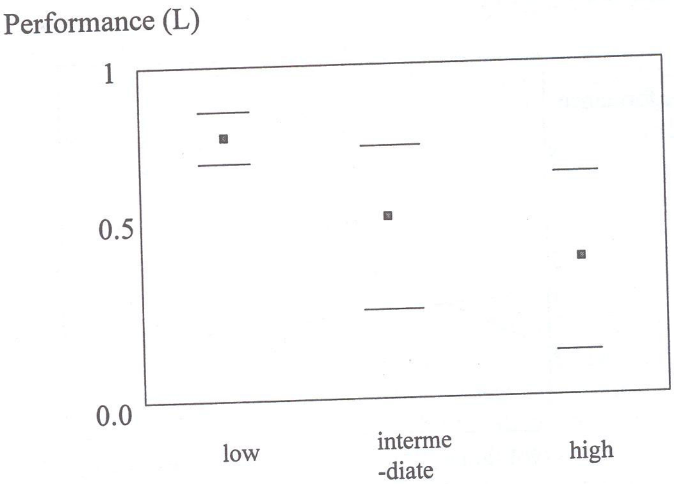

Figure 5 Influence of situational complexity on secondary task performance

Figure 5 shows the decrement in highly complex traffic situations and figure 6 shows that older drivers compensate effectively by allocating less attention to the secondary task.

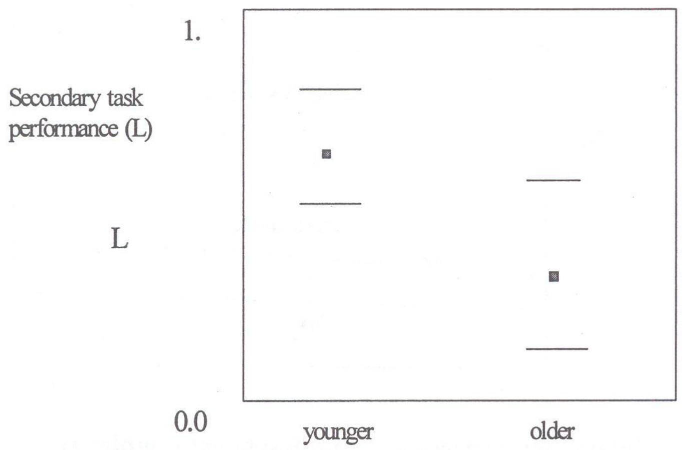

Figure 6 The influence of age on secondary task performance

A more detailed picture of the allocation strategy of elderly drivers emerges from the comparison of the secondary task performance when an external signal (beep) triggered the attentional shift and when the subjects attended voluntarily to the secondary task (see figure 7).

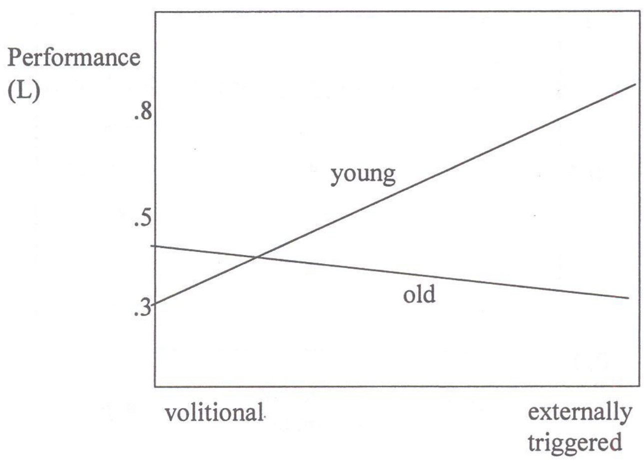

Figure 7 Interaction of attention allocating mode (externally triggered versus volitional)

While younger and older drivers show about the same performance level in the voluntary-shift condition, the externally-triggered shift condition has a strong effect on elderly drivers (comparative impairment about 270 %). In the field experiment this effect was further analysed with the result that from the glance behaviour of the subjects it can be concluded that older drivers have a more or less fixed scanning strategy for instruments (including the display for the secondary task), namely they attend to the instruments according to a time schedule where the frequency depends on the importance of the information. Insofar they cannot fully utilise the diagnosticity of externally triggered signals but are instead annoyed by them as becomes apparent from the video-based critical-incident interviews after the driving.

In general, the pattern of results in the simulation and the real driving is consistent when comparing the effects on lateral stability in the simulation with the frequency and severity of traffic violations in real driving.

In both experiments, questionnaire data (NASA-TLX and subjective workload ratings (Basler Befindlichkeits-Fragebogen) were not sensitive enough to detect the task and situation influences; perhaps because the questionnaire data were reported after the driving task (however immediately) and this delay is apparently sufficient to cancel out the specific influences on the workload. For further experiments loud thinking and immediate reporting are planned with the - expected - drawback of an interference with the main task.

In conclusion, the experiments have shown that younger and older drivers apparently use different strategies in allocating attention in dual-task situations, this should have consequences for the design of assistive technology in traffic. Furthermore, despite the observation that older drivers overestimate their driving competence (Huerlimann and Hebenstreit 1975), they apparently compensate effectively by concentrating on the primary task. Finally, the few but significant cases of 'accidents' in the simulator experiment reveal that - at least for unilateral visual impairment - the position of the displays supporting planning activities is crucial when used while driving.

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