Editorial

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Biographical notes: Neville A. Stanton (Professor of Human-Centred Design) was awarded the Institution of Electrical Engineers Divisional Premium Award for a paper on Engineering Psychology and System Safety in 1998. The Ergonomics Society awarded him the prestigious Otto Edholm medal in 2001 for his contribution to basic and applied ergonomics research. He is a Chartered Occupational Psychologist registered with The British Psychological Society, a Fellow of The Ergonomics Society and a Fellow of the RSA. He has a BSc in Occupational Psychology from Hull University, an MPhil in Applied Psychology from Aston University and a PhD in Human Factors, also from Aston.

1 Introduction to Human Factors (HF)

The purpose of this special issue was to encourage researchers and engineers to report on the state-of-the-art HF studies into vehicle design. These reports include reviews, case studies, simulator studies, and on-road studies of HF related to vehicle design, vehicle systems and in-vehicle technology (including the design of future vehicles and future vehicle technology). 'Human Factors Aspects' refers to the physical, physiological, psychological and social constraints, concerns and considerations in 'Vehicle Design'. The special issue has captured a broad spectrum of research that is currently being conducted and reflects some of the diversity in HF studies. HF is a relatively new scientific discipline, as it has only been around for some 60 years. It is distinct from psychology, engineering, and design because the focus of analysis is on the interaction between people and technology rather than people or technology, which necessarily means that HF requires an interdisciplinary approach. HF scientists are concerned with human performance in technological systems with a view to optimisation of the design of the system in terms of effectiveness, safety, comfort and well-being. Like all scientific disciplines, HF is characterised by theoretical and methodological development together with empirical investigations. The latter tend to shift between studies in the world and studies in the laboratory. All of the characteristics mentioned above are represented in the various papers presented in this special issue.

2 Psychological factors

An introduction to the psychological factors in driving automation is presented in the discussion paper by Stanton et al. (The psychology of driving automation).

The discussion paper benefits from an interaction with Professor Don Norman, who is acknowledged as a pioneer in the field of HF. This paper identifies six key psychological dimensions that are likely to impact on the driver when faced with advanced automobile automation: locus of control, mental models, mental workload, situation awareness, stress and trust. These factors are likely to interact with each other and automation in a complex and unpredictable way. The discussion paper considers the possible effects of automation on the driver and in particular on the implications of reduced mental workload. Central to the discussion are the concerns of driver mental underload, when the driver is left to the task of monitoring automatic systems that are controlling the vehicle. MART (Malleable Attentional Resources Theory) is offered as a predictive model of the effects of underload on performance, hypothesising that attentional resources are yoked to task demand. MART shows vehicle designers that one cannot assume that by reducing mental demand will mean that drivers have spare attentional capacity. Rather it suggests that reduction in mental demand in the driving task (through driving automation) will likely lead to corresponding reductions in attentional resources in the driver. This is probably to counter-intuitive prediction for those without HF training, and illustrates the importance of considering HF in vehicle design. The paper finishes with two visions of the future, one the automation utopia and one the automation nightmare. It is suggested that the incorporation of HF into vehicle design is what will prevent the former becoming the latter.

Walker et al. (Easy rider meets knight rider) picks up on the relationship between vehicle feedback and driver situation awareness, to propose that both implicit and explicit feedback are important determinants of diver/rider situation awareness. In particular, Walker et al. explore the differences between cars and motorcycles, in terms of the feedback that they are able to provide and the situation awareness that drivers and riders report from an on-road study. Motorcycles and car differ considerably on their power-to-weight ratios, degree of exposure to the environmental elements, and the directness of mechanical linkages between driver/rider controls and effectors. Drivers and riders took the same route around an on-road course, providing verbal protocols which were recorded. Analysis of the protocols showed that motorcyclists were significantly more situationally aware than drivers of cars. Riders vocalised more about the road environment and their own behaviour. Walker et al. suggest that motorcyclists' situation awareness is qualitatively different to that of car drivers. The lower levels of situation awareness of car drivers, inferred from the verbal protocols, could be due to their greater isolation from both the road environment and the mechanical systems in their own vehicles. Thus it is suggested that feedback deprived drivers have poorer situation awareness.

Young et al. (Driving automation: learning for aviation about design philosophies) consider the implication of advancing automation in automobiles. They suggest that 'driving automation' is shifting from lower level 'vehicle control' to a much higher level of 'driving control'. The implication of this shift is that rather than automation simply removing physical tasks from the driver (such as holding the vehicle at a constant speed), it is now removing cognitive tasks from the driver (such as deciding whether to brake or accelerate in response to other road users – and even making emergency response interventions in some cases). The basic premise for the paper comes from consideration of the automation philosophies in aviation. Apparently opposing views are held by the two leading aircraft manufacturers, one adopting primarily a hard automation philosophy and another adopting primarily a soft automation philosophy. Hard automation sets flight envelope limits that the pilot cannot exceed whereas soft automation allows the pilot to exceed these limits. The question is, for the purposes of vehicle automation, “should we adopt ‘hard’, ‘soft’ or ‘mixed’ automation protection systems?” Unfortunately the picture is not clear-cut. Analyses of aviation accidents show a mixed outcome. Whilst hard automation may have led to slightly more automation-related accidents, soft automation may have led to slightly more pilot-related accidents. Whether or not these lessons can be transferred to automobile driving automation is a moot point. The driving environment is more complex and less predictable than the flying environment. By way of offering some consolation, Young et al. suggest that hard automation might be better suited to lower level ‘vehicle control’ whereas soft automation might be better suited to higher level ‘driving control’.

3 System safety and failure

Kazi et al. (Designer driving: drivers’ conceptual models and level of trust in adaptive cruise control), consider two key psychological aspects of adaptive cruise control. Kazi argues that a longitudinal study is required, as the dynamics of conceptual models and trust mean that changes occur as the driver gets used to the system. It was hypothesised that different levels of system reliability would affect the development of driver trust in the system and conceptual models of the system in the driver. The level of reliability was manipulated by altering the rate of system failure. The experimental study took part in a driving simulator over ten days. This offered compressed experience of the system and, although ten days is relatively short time to experience a new system, it is a relatively long time compared to most experimental studies. Kazi et al. report that trust in the adaptive cruise control system increases over time, but the absolute level of trust might not be appropriate with a given level of reliability. Drivers’ conceptual models of the adaptive cruise control system were not very well developed at the end of the ten days (even with the compressed experience), suggesting it takes much longer for drivers to understand the intricacies of the system properly.

Jamson et al. (Driver response to controllable failures of fixed and variable gain steering) also used a driving simulator to investigate system failure, but this time it was focused on steering control systems. Fixed gain steering keeps the steering gain constant despite the speed of the vehicle whereas variable gain steering offers a direct ratio between vehicle speed and steering gain. The latter approach makes the vehicle much easier to control. There are concerns over the effect of failures with variable gain steering, as it would suddenly behave like fixed gain steering, although this would be most noticeable at lower speeds. The experimental study simulated failure of both fixed and variable gain systems. Under normal operating conditions, driver expressed a preference for the variable gain steering system. The data suggest that variable gain requires fewer corrective inputs from the driver. Under failure conditions, the variable gain steering appeared to be no more difficult to control than loss of power assistance in a fixed gain system. This is encouraging news, as it seems that drivers were able to cope with the failure without any detrimental effects.

Jenkins et al. (A new approach to designing lateral collision warning systems) consider ways in which drivers might be assisted in avoiding potential collisions through the optimal design of a warning system. An ecological perspective is taken to devise interface design concepts. The design begins with a work domain analysis of the lane-keeping task, with the overall purpose of the system being defines as "avoiding unsafe and unintended lane departure and being informed of other drivers encroaching on the host vehicle". The relationship between the overall values of the system and the system constraints (specified in terms of psychological and technological constraints) is explored in the means-ends analysis. The ideas from Gibson's perceptual theory of 'field-of-safe-travel' were used to influence the design of the visual interface. The interface design was intended to convey potential hazards in the driver's immediate 'field', represented by the proximity of other road users. Experimental studies were conducted to compare different designs in a driving simulator. An obvious auditory advantage was shown. Drivers' responses to auditory displays were twice as fast when compared to their responses to visual displays. The best combination of auditory and visual display was proposed and the usefulness of the 'field-of-safe-travel' theory was illustrated.

4 Pedestrian and driver protection

Jamson and Jamson (Safety implications of a pedestrian protection system: the driver's point of view) consider the potential impact of a deployed active bonnet system on the driver's visual scene. Undoubtedly the active bonnet system, when deployed, would partially obscure the driver's view of the road ahead. The safety benefits of the system are mainly to the pedestrian if struck by the vehicle. Conventional bonnets do not protect the pedestrian from head injury whereas the active bonnet system potentially offers more protection if the pedestrian is struck by the front of the vehicle. It is argued that benefits of such a system would be substantial; up to a 30% reduction in the head injury criterion. The question addressed by this paper is the effect of the restricted view for the driver due to the deployment of the active bonnet system at a time when an unimpeded view of the road ahead might be most needed, i.e., when the vehicle has struck a pedestrian. Jamson and Jamson compared the effects of different visual occlusion times and eye heights. The research suggests that the greater the visual restriction, the greater the braking by the driver; longer occlusions are associated with more forceful braking. Shorter occlusions did not appear to affect braking force adversely. This suggests that the design of active bonnet systems should try to minimise the duration of the visual restriction to the minimum practically possible.

Álvarez-Caldas et al. (Head injury criterion: the best way to evaluate head damage?) are concerned with the injury that could be sustained by drivers and passengers in the event of an accident. In particular, the focus of the paper is on the potential brain trauma that could result from head injuries. Álvarez-Caldas et al. consider developments in the head injury criterion. They expressed some concerns in the ways in which the studies have been conducted, such as the methodological limitations, assumptions and simplifications that have been made. One obvious limitation is that it would be unethical to use live human participants to experimentally inflict head injuries. Álvarez-Caldas et al. argue that there is room for improvement in the contemporary methods used to calculate the head injury criterion. Studies show that the head injury criterion does not provide sufficient protection for certain sorts of impacts. One example is the loads placed on the neck in accidents involving rotational acceleration. The head injury criterion does not take large physical differences between people into account.

Collaborations between researchers and motor vehicle manufacturers may produce better data, models, and ultimately an improved the head injury criterion.

5 Systems analysis

In the final paper in the special issue, Salmon et al. (Work domain analysis and intelligent transportation systems: implications for vehicle design) take a high-level, strategic, transportation systems, perspective using work domain analysis. It is argued that rather than implementing systems individually, a strategic approach is more likely to be effective. Work domain analysis enables designers to explore the constraints of a system, by mapping out purposes and functions in a logical and explicit manner. Salmon et al. present the abstraction decomposition space for the road transport system in Victoria, Australia. A detailed example shows how the overall functional purpose of the system may be decomposed into abstract, generalised and physical functions. This analysis serves as the basis for consideration of the information requirements for intelligent transportation systems. Thus, rather than considering the merits of individual technologies in isolation, they can be considered with respect to each other and the wider system within which they are intended to operate.

6 Conclusions

In conclusion, the four themes for this special issue on HF in vehicle design have been: psychological factors, system safety and failure, pedestrian and driver protection, and systems analysis. These themes are indicative of HF research into drivers and driving. From the research presented in the special issue, it is possible to summarise some take-home messages. These are as follows:

- reducing driver workload can have the counter-intuitive effect of reducing the drivers' attentional resource pool
- psychological factors important to driving automation are likely to include locus of control, mental models, mental workload, situation awareness, stress and trust
- the richer implicit feedback provided to motorcyclist from their machines helps them to be more situationally aware than drivers of cars
- hard automation may be suited to lower-level vehicle control whereas soft automation may be suited to higher-level driving tasks
- driver's model of, and trust in, automated systems may not well matched to the operation of the system in the shorter-term
- drivers seem to be able to cope with the failure of variable gain steering without any adverse effects
- the 'field-of-safe-travel' is a useful theory when designing driver interfaces for collision avoidance systems

- active bonnet systems need to minimise the duration of the visual restriction to the driver as far as practically possible
- greater collaboration between researchers and manufacturers in the research and development of the head injury criterion is required
- work domain analysis offers a systematic and systemic methodology for the analysis of ground transport and intelligent transportation systems.

This special issue shows that HF theories, methodologies and empirical investigations (both on the road and in driving simulators) have much to offer vehicle designers and engineers. It is hoped that this special issue has illustrated some of the benefits of HF work and convinced engineers and designers to engage with HF in their work.

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