



The impact of smart driving aids on driving performance and driver distraction

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ABSTRACT

In-vehicle information systems (IVIS) have been shown to increase driver workload and cause distraction, both of which are causal factors for accidents. This simulator study evaluates the impact that two prototype ergonomic designs for a smart driving aid have on workload, distraction and driving performance. Scenario complexity was also manipulated as an independent variable. Results showed that real-time delivery of smart driving information did not increase driver workload or adversely affect driver distraction, while also having the positive effect of decreasing mean driving speed in both the simple and complex driving scenarios. Subjective workload was shown to increase with task difficulty, as well as revealing important differences between the two interface designs. The findings are relevant to the development and implementation of smart driving interface designs in the future.

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1. Introduction

1.1. Background

Modern vehicles contain an increasing amount of instrumentation, as a combined consequence of factors including the motivations of vehicle manufacturers, advances in technology and consumer demand. However, this added information available to the driver raises significant ergonomic concerns for driver mental workload, distraction and ultimately driving task performance. Whilst the implementation of legislation designed to reduce driver distraction – namely the banning of hand held mobile phone use (Young, Regan, & Hammer, 2003) – may help to tackle the symptoms of the problem, a more ergonomic approach would be to treat the cause by focusing on the appropriate design of in-vehicle information systems (IVIS).

Research completed for the ‘100-car naturalistic study’ in the US suggests that driver inattention accounts for almost 80% of crashes and 65% of near crashes (Klauer, Dingus, Neale, Sudweeks, & Ramset, 2006). Statistics from the UK and US accident databases show that driver distraction (a subset of inattention) accounted for between 2% (Mosedale, Purdy, & Clarkson, 2004; Stevens & Minton, 2001) and 8% (Stutts, Reinfort, Staplin, & Rodgman, 2001) of accidents respectively. Although these analyses found little evidence of distraction from IVIS systems, this is likely due to the age of the database being interrogated (Stevens & Minton, 2001, used data from 1985 to 1995). Nevertheless, as has been widely reported, there has been an increasing emphasis in recent times on the role that IVIS-related driver distraction plays in the number and severity of road accidents. This issue will only become more apparent with the increased number and sophistication of in-vehicle information systems available (Stevens & Minton, 2001).

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Whilst the presence of such secondary tasks can increase the potential risk of an accident or incident, it has been suggested that drivers may have up to 50% spare visual capacity (Hughes & Cole, 1986) during 'normal' driving, suggesting that some secondary tasks may be conducted with no subsequent increase in crash risk. Therefore, other contributing factors also have to occur at the same time for this risk to manifest itself (Angell et al., 2006). Contributing factors may include the presence of a junction, urban driving or unexpected events. Such factors can impair the reactions of a distracted, or overloaded, driver since their spare attentional capacity has been absorbed by the secondary task. With the increasing prevalence and potential of new IVIS products coming to market, this spare capacity could soon get accounted for, thus creating workload issues if not carefully managed. One such area for new IVIS devices are regarding fuel efficient or safe driving, which combined form the basis for 'Smart Driving' (Young, Birrell, & Stanton, 2011).

1.2. IVIS for smart driving

Within the European Community, road transport accounts for approximately 15% of greenhouse gas emissions and resulted in 38,875 deaths a year (Eurostat, 2011). As a result of additional legislation and an increase in consumer awareness, motor vehicle manufacturers have started to embrace the 'eco revolution'. As well as developments in low carbon vehicle technologies, more recently the market has seen a number of 'green' IVIS interfaces aimed at encouraging environmentally friendly driving. Meanwhile, safety concerns continue to drive progress with advanced driver assistance systems (ADAS), many of which include an additional interface to the driver. The proliferation of such systems and information overload in the car could pose a potential threat to driver distraction, resulting in the opposite effects to those desired (Young et al., 2011).

A UK led project called Foot-LITE aims to bring information on safety and fuel efficiency together on a single, integrated, adaptive interface, providing driver feedback and advice on aspects of safe and green driving styles. The system ostensibly comprises two aspects: an in-vehicle system providing real-time feedback and advice on driving style, coupled with a post-drive, PC based data logging system which aims to encourage longer term behavioural changes and help inform transport choices. In the current paper, our focus is on the ergonomics of the in-car interface – with the aim of eliciting the desired 'smart' driving behaviours whilst avoiding negative effects such as distraction or overload. In terms of the Foot-LITE project 'Smart' driving is defined as that which is both safe and fuel efficient. A previously completed Cognitive Work Analysis (CWA; Rasmussen, Pejtersen, & Goodstein, 1994; Vicente, 1999) – which defined project constraints and detailed principal information elements which could be presented to the driver – highlighted several behavioural aspects the system would hope to address. These were correct gear change (including the appropriate use of block changes) and maintaining a consistent speed profile facilitated by planning ahead in order to avoid unnecessary acceleration and braking events, both of which relate to fuel efficiency. With respect to safety, maintaining an appropriate headway (distance to you and the car in front), lane position and lane deviation were identified (Birrell, Young, Jenkins, & Stanton, 2011).

1.3. Foot-LITE interface designs

A rigorous ergonomic methodology has been adopted in order to minimise distraction to the driver as a result of the in-vehicle aspect of the Foot-LITE system. In order to achieve the goals of changing driving style while avoiding negative effects of distraction or increased workload, the in-car interface in particular needs to be designed with the driver's information requirements in mind. Two human machine interface (HMI) designs were conceived, both very different to each other, but both displaying the same information elements as described above (namely gear change and acceleration (eco), and headway and lane deviations (safety)), thus maintaining information equivalence across each – it is simply the format of presentation which varies between the two interface designs.

The first design concept was generated based on principles of Ecological Interface Design principles (EID; Burns & Hajdukiewicz, 2004). Specifically relevant to the Foot-LITE project EID (Fig. 1¹) offers to dynamically reflect the driving environment and integrate complex information onto a single, direct perception display (Burns & Hajdukiewicz, 2004). Safety and Eco information is grouped together on the ecological display – termed in the rest of the paper as 'EID' – with all parameters being shown on the screen at the same time, and changing in real-time depending on the driver's inputs.

As an alternative to the EID concept, a more conventional dashboard-type interface (referred to as 'DB'; Fig. 1) has also been developed according to best practice in the human factors literature (such as the European Statement of Principles on human machine interface for in-vehicle information and communication systems; EC, 2008). Initially based on a vehicle instrument panel layout, the DB interface consists of warning icons (derived from ISO 2575 (2004)) and textual information. The basic principles of the design are that only one parameter is shown to the driver at any one time, this being the parameter which was deemed to be the highest priority, the interface then 'scrolls' through the relevant warning icons. The DB design is intended to offer familiarity to drivers being akin to a standard instrument panels, warning messages and icons available in most vehicles. For a more detailed description of the interface designs evaluated in this study please refer to Young and Birrell (2010).

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