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Optimising landmark-based route guidance for older drivers

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ABSTRACT

In-vehicle navigation systems (IVNS) have the potential to benefit older drivers, reducing stress associated with way-finding and providing on-trip support, especially in unfamiliar locations. However, existing IVNS present challenges to usability, resulting in lack of uptake and over-reliance on pre-trip planning.

This paper presents research aimed at identifying features that make IVNS user-friendly and appropriate for older drivers. Studying navigational performance within a simulated driving environment, it focuses on the use of landmarks with route guidance information, and the most appropriate method of information provision (audio only, visual only or a combination of audio and visual). It also assesses potential gender differences that might arise with landmark-based navigational information.

Solutions include use of appropriate roadside landmarks, and information delivered through a combination of audio and icon-based visual format. These features result in lower workload and fewer navigational errors. The audio/visual modality reduces the hazard of distraction by landmarks resulting in fewer visual glances and lower glance duration to the roadside compared to other modalities.

Design and provision of IVNS tailored to older drivers' needs can make a considerable contribution to maintaining individual mobility for longer.

1. Introduction

Navigation, in its broadest sense, is to travel safely, efficiently and independently from one point to another (Burns, 1999; May, Ross, & Osman, 2005). It may involve two distinct but often interrelated themes: pre-trip planning and way-finding. Pre-trip planning encompasses the navigational preparations many (but not all) people make before undertaking a journey, whereas way-finding can be defined as the on-trip decision-making process the driver is required to undertake to reach their destination (Burns, 1999).

Navigation involves multi-level cognitive processing and attracts much theoretical and practical interest (Ishikawa, Fujiwara, Imai, & Okabe, 2008). Older adults often experience difficulty in navigating because age-related decline in cognitive, perceptual and motor skills (including spatial learning and memory) can impede the mental representation of a spatial environment (Forlizzi, Barley, & Seder, 2010; Kim, Hong, Li, Forlizzi, & Dey, 2012; May et al., 2005; Yamamoto & DeGirolamo, 2012). Therefore, older adults may face challenges in navigating a journey from memory. Moreover, they will often want to avoid certain situations like heavy traffic, driving at night or driving on unfamiliar routes – a process called self-regulation (Burns, 1999; Charlton, Oxley, Fildes, Oxley, & Newstead, 2003; Rabbitt, Carmichael, Jones, & Holland, 1996). Older drivers

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often plan alternative ways of achieving their goal or adapt their behaviour in order to reach a required destination (Banister & Bowling, 2004; Metz, 2000, 2003).

Bryden, Charlton, Oxley, and Lowndes (2013) conducted a large-scale survey with 534 drivers aged 65 and over to examine their way-finding strategies and navigational behaviour. From this sample, 60% of the participants reported difficulties with way-finding. When reviewing strategies for an unfamiliar journey the researchers found that using a map while driving was the most popular (62%), reading a map while on the roadside was second (55%) and reliance on memory (38%) third. 33% of older drivers would create written instructions or a drawn map to assist them. Only 10% would use an in-vehicle navigation system (IVNS). Moreover, this research found that when older drivers have difficulties with way-finding they are likely to ask a passenger to assist them in the navigation task.

1.1. Older drivers and IVNS

In Vehicle Navigation Systems (IVNS) can benefit older drivers as they assist with the pre-trip planning and way-finding tasks of driving (Burnett & Lucas, 2010). However, they are not widely used by this demographic with older drivers more often navigating with conventional maps complemented with written notes (Bryden et al., 2013; Musselwhite & Haddad, 2010). Yet the scope for using conventional maps to plan and then way-find a journey is restricted, as paper maps cannot provide the current location, rather the driver interprets his/her location from the map. When relying on paper maps, a driver will observe landmarks and keep them in his/her working memory, using them to determine current location (Daimon & Kawashima, 1995).

IVNS generally provide the current location on a map-based visual display along with the estimated arrival time and distance to next turn. As the visual display operates at all times, it is not necessary for a driver to retain information in his/her working memory. Drivers will still search for landmarks but determine that they are on the correct road by observing the visual display. This reduces the need for a cognitive map, that is, a mental representation of the spatial environment and use of this representation to navigate that environment (Chown, Kaplan, & Kortenkamp, 1995; Kitchin, 1994; Lynch, 1960). Cognitive maps can be more challenging for older adults because of age-related decline in cognitive skills, spatial learning and memory (Iaria, Palermo, Committeri, & Barton, 2009; Liu, Levy, Barton, & Iaria, 2011).

Visually, an IVNS can be either a moving map display or an icon-based display. However, display complexity and visual demand can be a challenge for older drivers. In a simulator study where drivers of all ages followed a route on an IVNS, the older drivers' mean glance duration towards the display was 0.98 s, compared to the younger drivers' average of 0.84 s (Zhang, Wang, Jia, & Dong, 2012). An on-road trial with 32 participants found that older drivers' mean glance towards a moving map-based display was 1.08 s compared to the younger participants' 0.83 s (May et al., 2005). There are clear implications in these findings for driver workload, distraction and safety imposed by a moving-map format (Birrell & Young, 2011; Pak, Czaja, Sharit, Rogers, & Fisk, 2008).

Supplementing the visual component are distance-to-turn audio instructions. Spoken instructions are crucial to safe and effective IVNS (Dalton, Agarwal, Fraenkel, Baichoo, & Masry, 2013), whilst for older drivers, audible information is preferable to the visual display in terms of reduced visual and cognitive demand (Jensen, Skov, & Thiruravichandran, 2010; Moldenhauer & McCrickard, 2003).

1.2. Navigation with landmarks

Landmarks are vital in determining orientation and current location. Lynch (1960) described landmarks as external reference points that are easily observable. Other researchers have provided alternative definitions, but a consistent finding is that landmarks are a useful form of navigational information, acting as a tool to understand spatial surroundings and navigate the environment (Nothegger, Winter, & Raubal, 2004; Roger, Bonnardel, & Le Bigot, 2011).

Underpinning this research is work by Burnett (1998) that produced a list of the top ten scoring landmarks based on a number of questionnaire-based and road trial-based studies, and geographic location. The resulting landmarks are specific to the UK: traffic lights, pedestrian light-controlled crossing ('Pelican'), bridge over road, hump-backed (arched) bridge, petrol station, monument, superstore, street name sign, railway station, and church. A further study (Burnett, Smith, & May, 2001) involved 32 participants (16 male, 16 female; age range 22–60) who were asked to write down detailed route plans for an unfamiliar journey. This aimed to understand the characteristics of what makes a good landmark for navigation. The frequency of landmark mentions was analysed, and the contextual differences of the landmark types assessed. The research thus proposed characteristics of 'good' landmarks as permanence, visibility, usefulness of location, uniqueness, and brevity (see Table 1).

Adopting the findings of Burnett et al. (2001), May et al. (2005) conducted an on-road trial to investigate the benefits to older and younger drivers in providing landmarks with audible route guidance information, finding that landmarks reduced the time spent glancing at the visual display, reduced navigational errors and positively influenced driver confidence, for both older and younger drivers. The authors concluded that the inclusion of landmarks could have significant benefits for older adults.

May and Ross (2006) implemented a road trial with 48 drivers aged over 21 using an IVNS providing visual arrows and verbal landmark information, as well as a visual map display. This study found that 'good' landmarks enhanced navigational performance, driving performance and confidence. In comparison, distance-to-turn information increased visual glances