



Compatible cognition amongst road users: The compatibility of driver, motorcyclist, and cyclist situation awareness

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ABSTRACT

Compatibility between different road users' situation awareness is critical to safe and efficient interactions between them. This paper describes an on-road proof of concept study conducted to explore situation awareness across three road user groups: drivers, motorcyclists, and cyclists. The aim was to test the assumption put forward by contemporary situation awareness theory that different road users interpret the same road situations differently, and to explore the extent to which these interpretations are compatible with one another. The study involved participants from each group negotiating the same pre-defined route using an instrumented car/motorcycle/bicycle. Based on verbal protocols provided en-route, a network analysis procedure was used to describe and analyse participants' situation awareness. The analysis revealed important differences both in the content and structure of each road user groups' situation awareness, along with evidence of incompatibilities at intersections. The implications of this are discussed along with recommendations on how to enhance compatibility between different road users.

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1. Introduction

Road users are not homogenous; each form of road transportation (e.g. driving, motorcycling, cycling) requires different physical and cognitive tasks for safe and efficient performance. Not surprisingly, evidence suggests that distinct road users, such as drivers and motorcyclists, interpret the same road situations differently (e.g. [Shahar et al., 2010](#); [Walker et al., 2011](#)). Whilst differences are inevitable and indeed appropriate, the key to safe interactions between different road users is some degree of compatibility between their situational interpretations ([Salmon et al., 2011](#); [Walker et al., 2011](#)). Without this, road users' awareness can become uncoupled and conflicts can arise ([Walker et al., 2011](#)). This is evidenced by road accidents involving different road users, such as 'right of way' accidents between cars and motorcycles (e.g. [Crundall et al., 2012](#); [Pai, 2009](#)) and left hand turn incidents involving cars and bicycles ([Johnson et al., 2010](#)). The concept of Situation Awareness (SA), which accounts for how humans understand 'what is going on' around them ([Endsley, 1995](#)), offers opportunity to investigate different road users' understanding of road situations. Despite this, to date SA has received scant attention in the road transport context ([Salmon et al., 2011](#)).

Recent calls for a systems theoretic approach to road safety research (e.g. [Larsson et al., 2010](#); [Salmon and Lenné, 2009](#)) argue

that interventions should be based on an understanding of how different road users interact with one another and the road environment. When this is coupled with the fact that incompatibility between different road users represents one of the key issues facing road safety practitioners (e.g. [Elvik, 2010](#)), the requirement to clarify exactly how SA differs across road users, and where incompatibilities arise, becomes manifest. Increased understanding of the incompatibilities between road users' SA at different road sites will inform more appropriate road design, training, and educational campaigns that consider all road user groups together rather than individual groups in isolation.

This paper presents the findings from an exploratory on-road proof of concept study of SA across three different road user groups: drivers, motorcyclists, and cyclists. The aims were, first, to test on-road the assumption that different road users interpret the same road situations differently, and second, to explore the degree of compatibility between each road user groups' SA across different road contexts.

2. Road user situation awareness and its assessment

Road user SA is defined as activated knowledge, regarding road user tasks, at a specific point in time. From a road user perspective, this knowledge encompasses the relationships between road user goals and behaviours, vehicles, the road environment and infrastructure. Contemporary situation awareness models (e.g. [Salmon et al., 2009](#)) and recent on-road study evidence suggests that SA

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differs across different road users (e.g. Walker et al., 2011). That is, different road users sample the environment differently and perceive and interpret the same road situations differently. These differences are likely both within road user groups (i.e. drivers have differing views to one another based on goals, experience, etc.) and across different road user groups (i.e. drivers have differing views to motorcyclists). Distributed SA protagonists argue that the level of compatibility between different agents' SA is key to efficient systems performance (Stanton et al., 2010); that is, compatibility between SA binds sociotechnical systems together. The compatibility between road users SA is thus one factor influencing the efficiency and safety of road system performance (e.g. Salmon et al., 2011; Walker et al., 2011).

The extent to which different road users' SA differs is contingent upon various factors, including the tasks that they have to perform (e.g. driving a car versus riding a motorcycle), the design of the road environment (e.g. infrastructure, signage, road markings), and their experience and goals. A key component of road users' SA, however, are genotype and phenotype schema (Stanton et al., 2009); genotype schema represent schema held in the mind of individuals which contain prototypical responses to specific situations, whereas phenotype schema represent the state specific activated schema which is brought to bear in a particular situation. These schema drive, and determine the content of, road user SA, since they direct exploration in the world (i.e. sampling of the environment), which in turn directs behaviour, which in turn modifies schema and so on (e.g. Neisser, 1976). Different road users possess different schema for the same road situations and Walker et al. (2011) argue that schema-related issues are likely to be at the root of incompatibilities between road users, including activation of the wrong schema, failure to activate the appropriate schema, and the mistimed activation (i.e. too early or too late) of schema. Put simply, if phenotype schema are brought to bear which do not incorporate other road users (and thus do not direct sampling of other road users), or the wrong schema are activated, then the interaction between road users is likely to be problematic. This is likely to include issues such as road users failing to see other road users (i.e. looked but failed to see errors) or failing to comprehend how other road users are likely to behave.

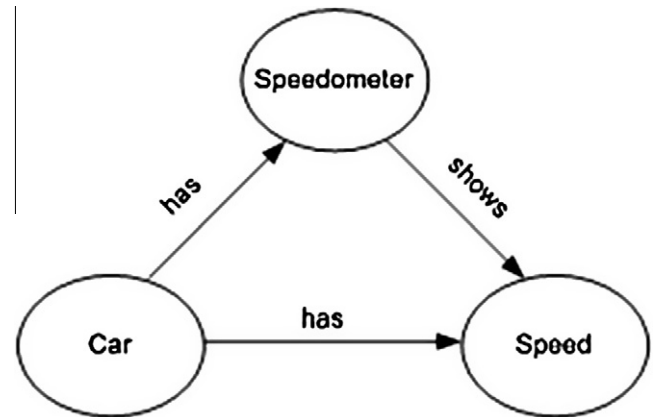


Fig. 1. Example relationships between concepts.

Explorations of how different road users assess the same road situation have previously been limited to simulation (Shahar et al., 2010) and video-clip-based studies (e.g. Crundall et al., 2012). Whilst these studies are useful, there is a pressing requirement to explore these differences whilst road users are engaged in non-contrived, naturalistic road scenarios. In the present study the interest was not to assess the 'quality' of road user SA against a normative ideal, rather it was to identify what different road user SA comprises in real world road situations, both in terms of knowledge and how different pieces of information are integrated to create this knowledge. The use of network analysis has become popular as a way of modelling the content of SA during real world activities, including in road transport (e.g. Salmon et al., 2011; Stanton et al., 2007; Walker et al., 2009, 2011). Specifically, the approach involves the use of propositional networks to describe the information underlying awareness, the relationships between the different pieces of information and also how different components of the system is using each piece of information. This is based on the notion that SA comprises information elements (or concepts) and the relationships between them, which relates to the



Fig. 2. Road sites and study route.

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