On the Influence of a Vehicle's Apparent Intelligence on Driving Behaviour and Consequences for Car UI Design

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ABSTRACT

We describe initial results form a car-simulator-based study. Specifically, we show a strong correlation between driver gazing behaviour and how intelligent they rated their car to be, indicating that human/car interactions are affected by the cognitive abilities ascribed to the vehicle by the driver.

Categories and Subject Descriptors

H.1.2 [**User/Machine systems**]: Information systems - Models and principles

General Terms

Design, Human Factors

1. INTRODUCTION

The present work in progress deals with how drivers perceive increasingly automated vehicles and how that affects their behaviour. More specifically, the simulator study, from which we present first results here, investigates whether the degree of *perceived* vehicle (or in-vehicle systems) intelligence correlates with changes in driving behaviour and expectations on human/vehicle interactions. Our overall hypothesis is that drivers will behave differently in a manner that affects driving style the more intelligent a vehicle *appears* to be. The latter can be influenced for instance by how interactive (communicating additional information to the user and accepting new commands) and/or autonomous (capable of carrying out certain tasks without driver interaction) the vehicle is. Here, we show that this appears to be the case. The present study is thus of interest to car UI designers since they may be able to influence this change in behaviour with their designs.

2. METHODS

2.1 Simulator, Environment, Task

It would go beyond the limits of this extended abstract to describe the experiment in detail. We therefore only describe aspects of our simulator-based study essential for the present results.

The simulator, equipped with an eye tracker, consisted of the front part of a real car (which the participants operated

AutomotiveUI'13, October 28–30 2013, Eindhoven, Netherlands.
Adjunct Proceedings

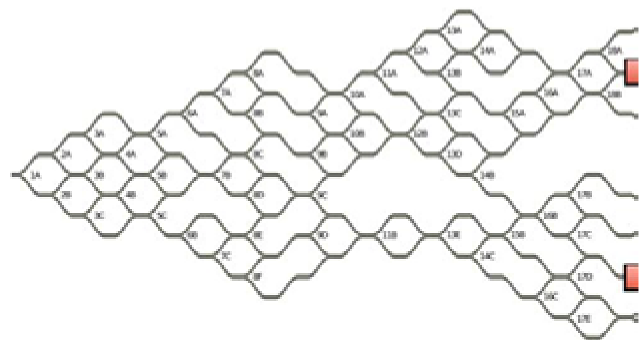

Figure 1: Environment map given to the participants. Far right boxes indicate both possible goals while the starting position is on the far left (before 1A). Junction numbers were always displayed in the simulator.

as they would a normal car) surrounded by a curved screen on which the environment is displayed. Participants were asked to drive through a road environment (see Fig. 1) towards goal positions as fast as possible while respecting traffic laws. They did so thrice. The first session served as a baseline in which traffic density was kept at a medium level, and only the upcoming junction number was displayed on the screen as an aid. In the subsequent sessions, participants experienced different traffic densities and had access to two types of navigation aids displayed heads-up on the screen: (1) Prior to each road junction, an arrow indicated which road to take and (2) additionally, a line of text justifying the choice was displayed (*e.g.* by claiming that the chosen road features less traffic). The overall purpose of the different mix of traffic densities and navigation aids described above was to provide a range of different driving experiences which may influence the apparent intelligence of the navigation aid.

2.2 Participants and Procedure

Participants were asked to fill out a pre-questionnaire on background and existing expectations. They then performed the driving task as described above. To assess their cognitive load, participants also carried out a secondary task (counting short but clearly audible beeps). After each session, they were asked to fill out a questionnaire. Twenty-four participants (8 female, 16 male) completed the experiment while six participants did not, due to a failure to show up on time (1) or simulator sickness (5).

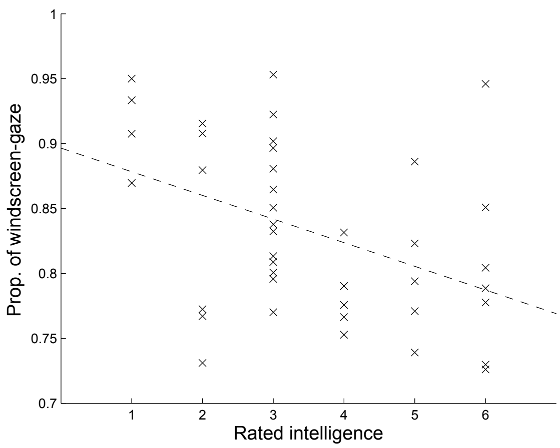

Figure 2: Scatterplot illustrating the inverse correlation between the proportion of total time drivers spend gazing through the windscreen and their own rating of the navigation aid's intelligence.

The questionnaires were used to identify match or mismatch of expectations and perceptions [2]. Each included a total of 17 statements, to be rated 0-6 on a Likert scale, targeting (a) apparent intelligence (b) performance of the driver and the system, (c) trust, (d) attitudes towards the system. Here, we only discuss first results pertaining to (a).

2.3 Data Collection and Analysis

Here, we considered three distinct variables. First, we measured driver behaviour through the proportion of the overall task duration that drivers spent gazing through the windscreen (here called *front gaze time* for brevity). We used an eye tracker designed to identify which particular region of interest the driver was looking at at any point in time (*e.g.* windscreen, mirrors, dashboard). Second, the performance on the secondary task is expressed as the participant's mean number of errors per occurring beep (a score of 0.1 would therefore indicate one error every 10 beeps) and is a measure of cognitive load, known to influence front gaze time [3]. Finally, the questionnaires assessed how intelligent participants judged their driving aids in the second and third trial. This therefore measures how intelligent drivers actually perceived the system to be rather than what may be expected given knowledge of the experimental design.

The fundamental question is whether or not the variables above are correlated. We expect in particular that change in behaviour is correlated with perceived intelligence (our core hypothesis). We therefore calculate Pearson's correlation coefficient r for each pair of variables while a T-test is used to determine the statistical significance of the correlation. Since some participants chose not to answer some of the relevant questions, forgot to carry out the secondary task or the eye tracker data was unavailable, the actual number of data points used here differ from the expected 48 (see the degrees of freedom ($n-2$) reported below).

3. RESULTS

We find, as hypothesised, that participants who rate intelligence higher had a significantly lower front gaze time ($r = -0.4255$, $p \approx 0.0005$, $df = 39$, see Fig. 2). Importantly, no correlation was found between the rated intelligence and the performance on the secondary task ($r = -0.0111$, $p > 0.9$, $df = 43$), indicating that cognitive load was not a decisive factor when assessing the intelligence of the navigation aids. The significant correlation between gaze time and rated intelligence is thus not just due the the effect cognitive load has on gaze. We also found (not discussed in detail here) that the most informative aid (arrows and text) tended to be rated more intelligent than arrows alone; the increase in gaze time in lower-rated conditions is thus not likely to result from the additional visual information. Finally, we found no significant correlation between the performance on the secondary task and front gaze time ($r = 0.1622$, $p \approx 0.3$, $df = 42$), indicating that the cognitive load here (including the secondary task) was not high enough to, by itself, significantly affect gaze time.

4. DISCUSSION

The results here show that changes in driving behaviour (gaze) correlate with the perceived intelligence of the navigation aids. This is notable since the more time is spent looking straight ahead, the less peripheral information is obtained (for instance from the rear view mirrors). As such, too much time spent looking ahead can be detrimental (as can too little) since it reduces the driver's ability to obtain a full picture of the traffic situation [3, 1]. The results here suggest that one way to influence driver gaze patterns is to manipulate how intelligent the vehicle appears to be through appropriate UI design.

As previously said, we also collected data pertaining to the driver's trust, detailed driving behaviour, performance and attitudes and the analysis thereof is ongoing. We next plan to address what factors influence perceived intelligence. This is not a trivial question since it is not necessarily the case that "better" or more "optimal" behaviour or even the automatic solving of more complicated tasks will directly influence this perception positively (in particular if the driver isn't even aware that this is happening).

5. ACKNOWLEDGMENTS

This research is part of a pre-study **CARS** funded by Vinnova (Sweden). The authors would like to thank Regina Johansson, Reetta Hallila and Emil Kullander at Volvo Cars Corporation for their technical assistance during the experiments.

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