

Investigation of Driver Comprehension of Traffic Information on Graphical Congestion Display Panels using a Driving Simulator

Andy Richards, Mike McDonald, Granville Fisher, Mark Brackstone
Transportation Research Group (TRG)
University of Southampton
Southampton
U.K.
email: acr@soton.ac.uk

EJTIR, 4, no. 4 (2004), pp 417-435

Received: March 2005

Accepted: February 2005

In the UK, the Highways Agency has been investigating the use of Graphical Congestion Display Panels (GCDPs) to display real-time congestion and journey time information relevant to drivers on sections of the trunk road network. A GCDP can potentially display a greater detail of traffic information than traditional Variable Message Signs (VMS). The research described in this paper has investigated driver comprehension of information that may be contained in such signs with a view to establishing prototype design guidelines. A key objective of this concept study was to design and undertake laboratory research to examine whether the content of traffic information messages displayed by the GCDPs could be readily understood, by using a simple driving simulator as a subject workload task. Sixty subjects participated in the simulator-based study and twenty sign designs were tested, with each sign classified as belonging to one of several different generic types with the best signs recommended to be taken forward for further research and testing. Two methods of measurement were used: verbal responses of the subjects to questions whilst driving the simulator and a written questionnaire after the experiment to record more detailed opinions. Although no single best sign design was identified, the research found that some sign design types were clearly more successful than others.

1. Introduction

The Transportation Research Group at the University of Southampton, in association with Atkins Transport Systems, were commissioned in 2002 by the Highways Agency in the U.K to undertake a study to investigate the use of Graphical Congestion Display Panels (GCDPs)

on sections of the UK trunk road network. Such signs display travel time information to enable drivers to make better informed route choices, resulting in improved network efficiency.

GCDPs have been used in Japan for some time, and within Europe, the concept of using signs to display graphical information is also now becoming increasingly popular. For instance, in the Netherlands, prototypes of graphical panels have been developed with implementation expected in the near future and in Germany (Munich), a pilot scheme has been in operation since April 2003. The sign designs are shown in Figure 1a and 1b, respectively (In Figure 1a, a black default setting may be changed to yellow and red according to congestion levels, with the display in 1b, using red to indicate delays). Although an area gaining in popularity, available literature on the design of GCDPs is rare, and hence in understanding the effects of their implementation it is worthwhile to consider work undertaken in, for example, the design of VMS and other signs.

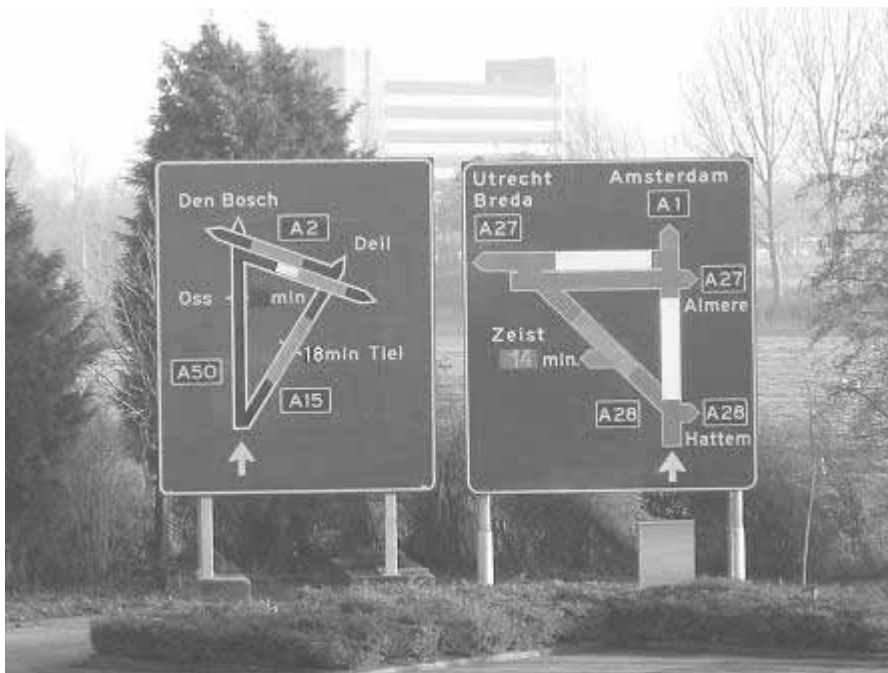


Figure 1a. Example of a Graphical Sign Prototype in the Netherlands (a black default setting may be changed to progressively yellow and red according to congestion levels)

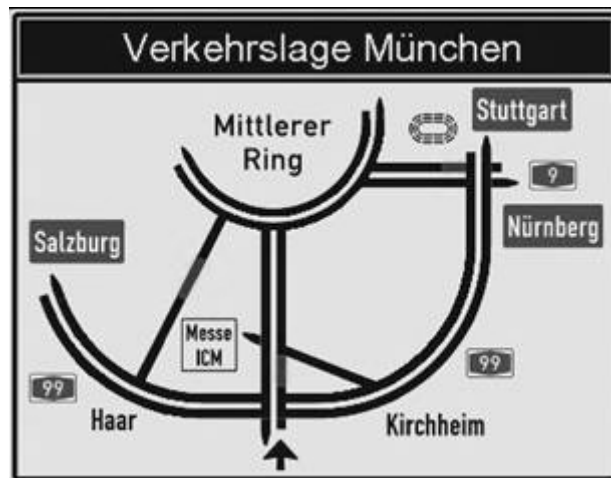


Figure 1b. Example of a Graphical Sign in Germany (a black default setting may be changed to red according to congestion levels)

Firstly, one must consider that the information displayed needs to be understood by a driver without causing excessive distraction or workload (Kantowitz, 1992, Dingus and Hulse, 1993). This work load may be assessed using a simulator to replicate the driving task, including vehicle control functions (Bonsall et al, 1997) and monitoring the drivers performance of a range of tasks including secondary tasks such as questions on material presented as used in this study. Research supporting the design of graphical panels in Munich (Schonfeld et al, 2000) has used a driving simulator, which consisted of a car with a large projection screen in front, on which the driver viewed a video sequence of the road which included the new traffic information signs. A similar simulator experiment has also been undertaken in the Netherlands (Alkim and Schenk, 2001) to test and compare comprehension of both regular VMS and Graphical Route Information Panels (GRIPs). In this experiment, three networks of differing complexity and road situations were used in the simulation and subject performance was assessed using measurements such as speed and following distance on the approach to each sign. It was found that increased message complexity reduced speed. Questionnaires were used to assess comprehension of the signs and the subject's preference for regular VMS or GRIPs.

Secondly, one may consider sign orientation, for example, a route map display can be presented either 'head-up' (i.e. the direction the vehicle is travelling is always 'up' on the display), or 'north-up', where the driver must mentally rotate the map to determine whether to turn right or left. This additional operation requires extra attention and processing time, and has been found to result in more errors as a whole (Dingus and Hulse, 1993), although one advantage is that the map does not constantly rotate as the vehicle heading changes, a factor previously found to adversely effect driver visual scanning (Antin et. al., 1990). The research findings from Munich (Schonfeld et. al., 2000) and the Netherlands (Alkim and Schenk, 2001) both recommended the use of a head-up display.

Additionally, one must consider the use of colour in signs, and although some guidelines have been developed these have not been widely adopted (Brockman, 1991). For instance, generally, there should be consistency in the use of colour codes, the avoidance of using colours from extreme ends of the colour spectrum (i.e. red and blue) next to each other, 'familiar' colour coding (e.g. red for hot), and the avoidance of using colour alone in order to

discriminate between items. Results of the Munich research on GCDPs (Schonfeld et. al., 2000) indicated that use of only two colours (red for congested and black for uncongested) was preferable as it limited sign complexity, and that a network display should be schematic but with sufficient definition to allow distinction of important characteristics. It was also concluded that showing both directions of traffic only in parts of the network was ambiguous, led to misinterpretation, and that the meaning of the colour yellow was vague, in contrast to red and green which were well understood. The results also indicated that generic location terms such as “Munich Centre” should not be used. However, the Drive Time system in Australia (Kloot, 1999), which uses roadside signs with colour strips to measure the level of congestion between roadway sections has used a three colour scheme of green (light traffic), yellow (moderate congestion), and red (heavy congestion).

Information provided to a driver also needs to be timely, allowing a driver sufficient time to see the information, decide whether it is relevant, and act upon it safely. Research in the USA (Dudek and Huchingson, 1986) found that motorists require about two seconds per unit of information, or one second per word presented on a VMS to perceive and process that information. The research also indicated that an 8-word message should be considered to be the maximum to be presented on a sign. It had earlier been found that information display format and style could affect a driver’s processing time and information perception (Dudek, 1979) which is additionally affected by the ageing process, which brings about a variety of changes in drivers’ visual functions and their cognition, with older drivers reporting problems with visual processing speed, light sensitivity, and near vision (Dudek and Ullman, 2002). There is little agreement also on the viewing time for which information should be visible. For example, studies in the USA to improve the effectiveness of Changeable Message Signs by flashing varying lines of the message (Kosnik et. al., 1990) used a viewing time of eight seconds, while Dutch research (Alkim et. al., 2000) used a viewing time of five to six seconds.

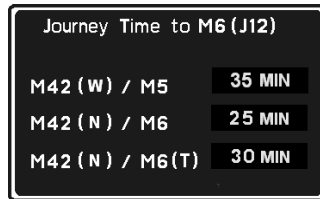
It is clear therefore that a wide range of issues need to be taken into account in sign design, and although there has been a wealth of research on the subject (other notable investigations include those of Lotan (1997) and Koutsopoulos (1994) into route choice behaviour, and those of Hall et. al. (1991), Hanowski and Kantowitz (1998), Ayama et. al. (2002) and Ihata et. al. (2002)), there are no clear and agreed guidelines at present. The test signs used in this study were constructed using a combination of recommendations from these earlier studies and other considerations revealed by Workshops undertaken in an earlier phase of the project. This resulted in a range of potential panel designs (shown in Figures 2a and 2b) for possible future trial on the Midlands motorway network in England. This network enables real route choice alternatives for many motorists travelling past the City of Birmingham (the surrounding motorway network forms the so-called ‘Birmingham box’, shown in stylised form by Signs 5 and 20 in Figures 2a and 2b). These signs have been the focus of the simulator investigations presented in later sections and may be broadly classified as belonging to one of 5 types which we chose to define as follows:

1. Link-based - signs 4, 9 and 11;
2. Text – signs 2, 6 and 16;
3. Graphical – signs 3, 7, 14, 15, 17, and 18;
4. Graphical segmentation – signs 5, 12 and 20;
5. Lane / junction-based (strategic) – signs 8, 10, 13 and 19.

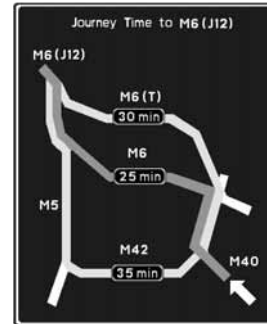
(Sign 1 is an existing motorway sign included within the simulator experiment to serve as a base case).



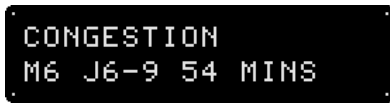
Sign 1 (existing sign)



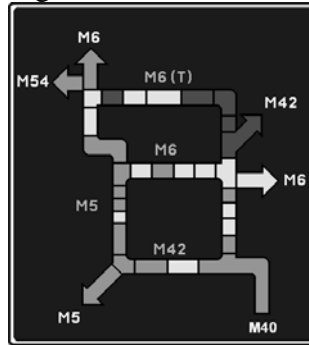
Sign 2



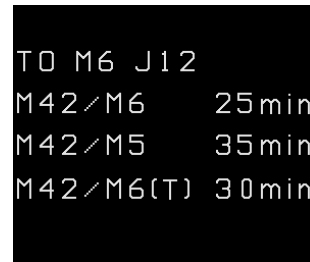
Sign 3 (& 17)



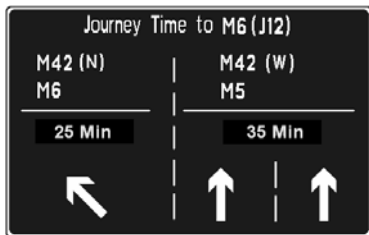
Sign 4



Sign 5 (& 12)



Sign 6



Sign 8



Sign 9



Sign 10

Figure 2a. Sign Designs Used in the Research Used in the Research. 17 and 12 are flashing versions of 3 and 5 respectively. Yellow and green routings are used in Sign 3 and 10, while a yellow green and red scheme is used in Sign 5.

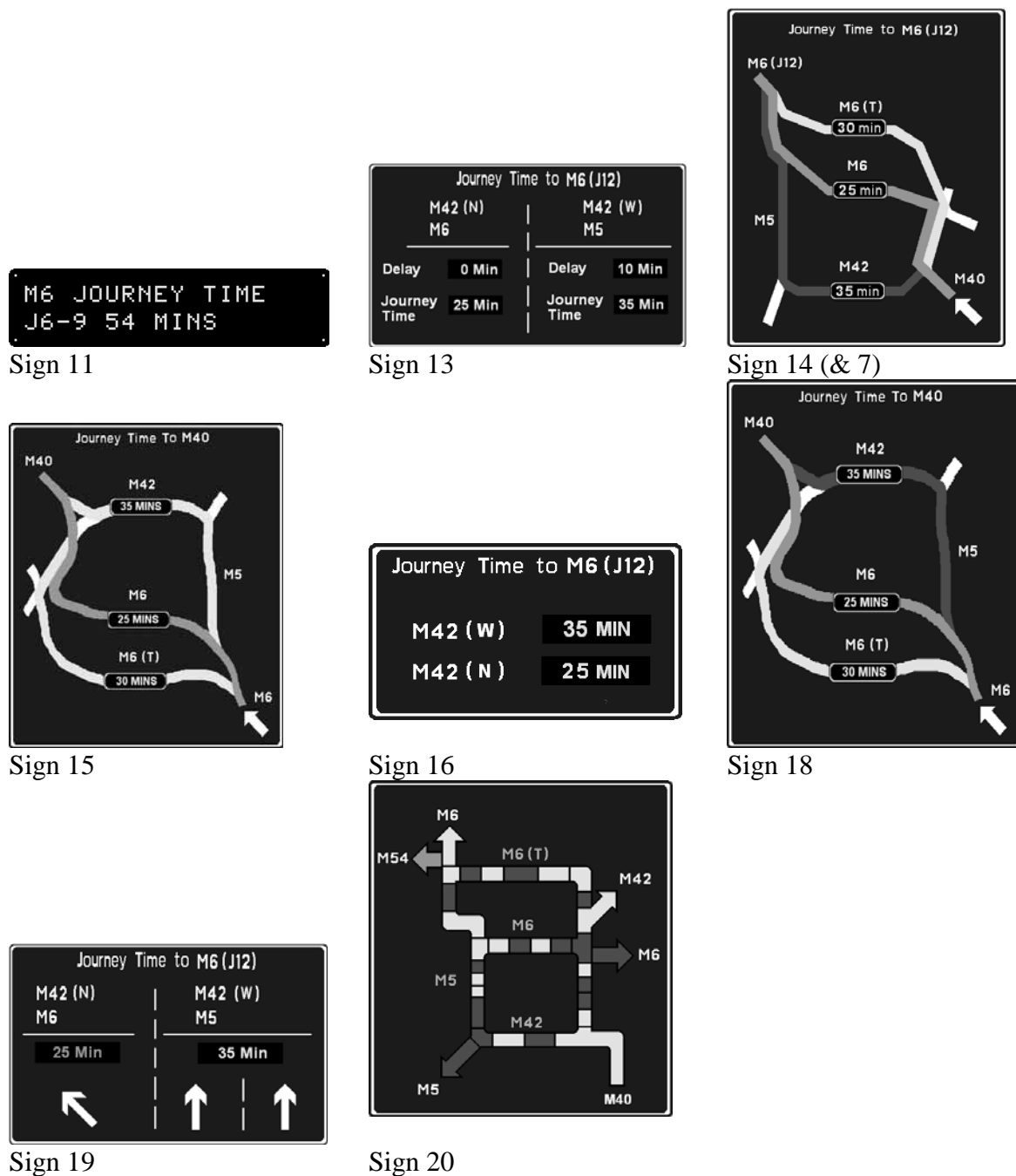


Figure 2b. Sign Designs Used in the Research (continued). 7 is a flashing version of 14. A yellow and green scheme is used in Sign 15, while a yellow, green and red scheme is used in signs 14, 18 and 20.

2. Research Methodology

The research described in this paper was an introductory study to test a range of GCDPs in laboratory conditions. An evaluation framework was prepared using guidelines developed by the CONVERGE project (CONVERGE, 1996). The assessment indicators used in this study

were user comprehension (measured using questionnaire and interview surveys), and driver performance based on simulator data outputs (not reported in this paper due to length restrictions).

2.1 Driving Simulator

A STISIM driving simulator (STISIM, 2003) was used to simulate a pre-programmed driving scenario, within which the subject controlled a vehicle using a steering wheel, accelerator and brake pedals. It is important to emphasise that the use of the STISIM driving simulator within this project was as a device to load the subject with a driving task whilst the GCDP signs were shown. It was not used as a full-scale driving simulator, and furthermore, the signs had no relevance to the route being driven, i.e. no strategic decisions were required, with the experiment being designed to test interpretation and comprehension only and not route choice.

The simulator used was a basic STI100 comprising a simple games controller interface. The simulator driving environment and GCDP were projected onto a large screen about four metres in front of the subject. The GCDP test signs were not integrated within the simulation environment but projected separately next to it for a fixed period of time. This ensured a higher quality resolution of the sign display than if it had been embedded within the simulator window. Alert prompts / markers were incorporated into the simulated scenario so that the subject was aware that a sign was about to be displayed at 150m. The full sign was displayed when the simulated vehicle was parallel with the marker (Figure 3). This simple approach in which a test subject only sees the sign under test for a set time and in a set position overcomes problems of how to ensure continued visibility of the sign up to the point at which it would be passed by the driver with a large subtended angle.

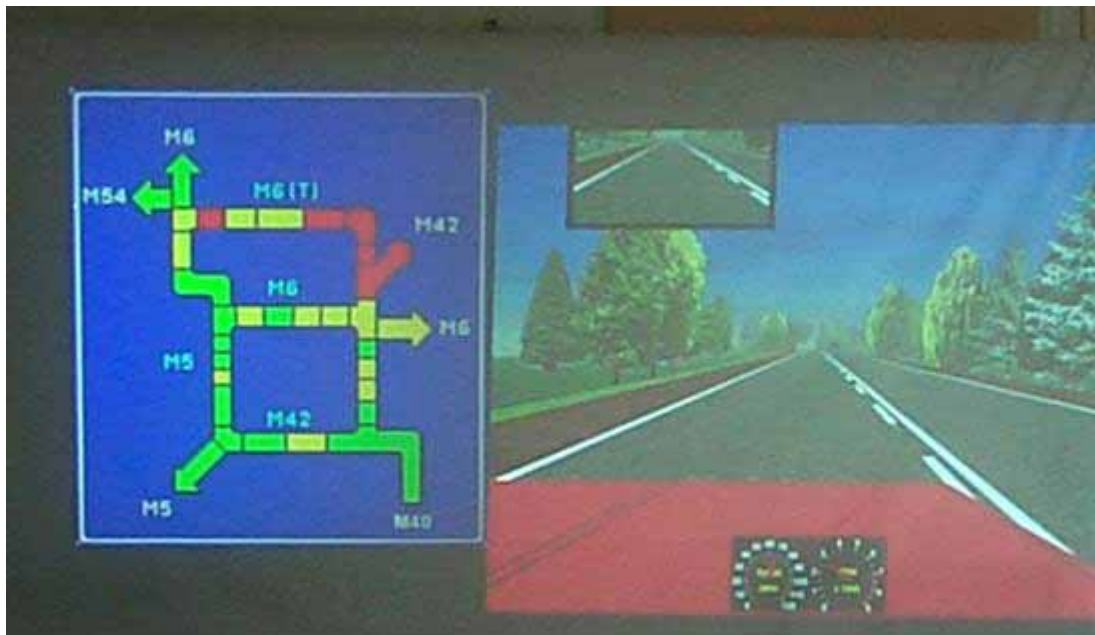


Figure 3 . Screen Display from an Experiment

Even though the GCDPs are intended primarily for motorway use, a single carriageway situation with oncoming vehicles was used to alleviate the monotony of a motorway oriented task, and encouraged the subjects to believe that each scenario was markedly different. Five driving scenarios were presented to each driver: a practice run, followed by four test runs, with a brief rest between each. Each scenario lasted for about five to seven minutes and included five test sign designs each located on straight sections of road at least 150m from any change in curvature in either direction, and permanently allocated to a specific location within a particular scenario. A consistent driving task difficulty level was developed for each scenario with each containing approximately the same number of bends, towns, inclines etc, although in differing orders.

2.2 Overview of Experiment Design

Sixty subjects participated in the study, 21 females and 39 males recruited from students and staff at the University and the local transportation authorities. Each held a full driving license. The mean age of the sample was 32.5 years with a standard deviation of 11.3 years. The average driving experience on UK roads was 10.30 years (standard deviation of 10.33) with a mean annual mileage of 7,430 (~12000 Km) (standard deviation of 5,157 (~8300 Km)). Finally the experimenter also subjectively assessed the subject's map-reading ability on a scale of 1 to 10 by assessing how quickly a subject was able to describe a course on a map between two points at opposite ends of the Midlands motorway network, resulting in an average subjective map-reading score of 7.72 (standard deviation of 1.73). The twenty signs tested in each experiment are shown in Figures 2a and 2b, with three of the signs having a duplicated base design, but with some flashing variant. Each sign had varying levels of complexity, which could be subjectively classified in terms of number of information units (Dudek and Ullman, 2002).

Each subject was given an introduction to the STISIM driving simulator and encouraged to become accustomed to the simulator by practising driving through the introductory scenario containing two dummy signs (of a current format which were not subsequently shown within the main body of tests). For a particular subject, the viewing time used for all signs was controlled to either four or six seconds. Four seconds is acknowledged in the UK as the maximum safe viewing time for a driver travelling at 70 mph (112 kph), and a six-second duration was also used to investigate the sensitivity of the viewing time.

During each test run, subjects were asked one question relating to the traffic information on each sign shown and their answer recorded. Examples of such questions included: Sign 2. Which was the quickest route?; Sign 3. What was the journey time on the M42/M5 route?; Sign 5. Which was the quickest journey time to the M54? Half the subjects were asked the questions before the sign was displayed, as if the driver was familiar with the route or had prior knowledge of such signs. The remainder were asked the questions after the sign design was shown i.e. associated with a driver unprepared in advance for the graphical information and akin to a subject absorbing and retaining all the information on the display panel. All subjects continued the driving task while being shown the sign and when questioned. The questions (which we term interview questions) were subsequently coded/scored as 1 if the driver answered the question correctly, 0.5 if the question was answered only partially correctly, and 0 if it was answered incorrectly or not at all. The viewing time used and type of questioning (before or after) were divided equally across the sample, ie. four combinations

of viewing time and questioning, each with a subset of 15 subjects. In addition, the scenario order, and thus the order of appearance of the sign designs, was split equally between subjects.

At the end of each experiment, the subject completed a written questionnaire containing illustrations of each of the sign designs, and, based on a description of a route to be driven was asked to provide a 1 to 10 rating of sign usefulness, an identification of any problems encountered, and their understanding of the sign based on sign specific questions, such as: Sign 2. What do you think the 3rd line M42/M6 means?; Sign 3. What do you think the green and red colours mean? Responses to these questions were coded from 0 to 1 in a similar manner as above, with the same interviewer and coder being used throughout the experiment to ensure consistency. Responses to the interview and questionnaire based assessments were analysed as part of a 7 factor experiment each of two levels:

- VIEWING TIME, 4 or 6 seconds
- TOIQ, (Time of Interview Question), Questions asked before or after exposure to the sign, in order to test whether drivers who undertake a search for particular information from the sign, are more likely to understand the sign than those who rely on recall.
- GENDER, Male or female;
- AGE, Age category (with categories being arbitrarily split at 35 years of age, with Older above, and Younger, below).
- MILEAGE, Mileage category (split into Low – those drivers whose annual mileage is 6000 miles or less, and High - those driving over 6000);
- EXPERIENCE, Driving experience category (split into Low – those that have 5 or less years driving experience on UK roads, and High – those that have over 5); and
- MAP, Rating (scale of 1 to 10) on a map-reading task, with those rating above 7 classed as Good, and those of 7 or below as Bad).

Note that for the purposes of this investigation we have restricted our independent variables to those that can clearly measured through the use of objective assessment criteria, and therefore no direct analysis has been undertaken for example according to the pre-defined sign groups or number of information units, with such (more detailed) research being the subject of subsequent, more stringent and comprehensive, investigations.

3. Research Results

In addition to the data from the simulator, the study generated two databases of results: the verbal responses to the interview questions and the written questionnaire responses. Analysis on the data was performed using the SPSS10 statistical package and examined the effect of the seven independent variables.

3.1 Response Accuracy – Interview Question

The average scores for the associated interview question for each sign are shown in Figure 4.

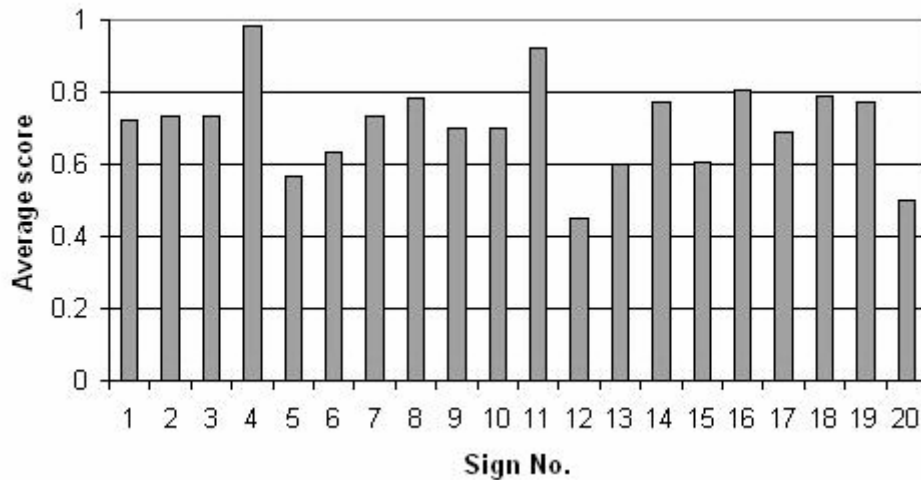


Figure 4. Average Interview Scores for each Sign

Signs 4 and 11 resulted in the highest number of correct responses, followed by signs 16 and 18. The signs that gave the highest number of incorrect responses were 5 and 12, 13, 6, 15 and 17. However, the level of difficulty of the question asked for each sign was not consistent. Statistical t-tests showed that:

- **VIEWING TIME.** The average scores generated from the two sets of viewing times across all 60 subjects were not significantly different ($p=0.544$, $df=19$). When the data was split into 'before' or 'after' responses, the scores were still not significantly different ($p=0.135$ and $p=0.937$, respectively, $df=19$).
- **TOIQ.** Average scores of the responses to the 'before' questions were significantly higher ($p<0.01$, $df=19$) than responses to the 'after' questions.
- **AGE.** The average scores of the younger drivers were significantly higher ($p<0.01$, $df=19$) than the older drivers.
- **MILEAGE.** The average scores of the lower mileage drivers were significantly higher ($p<0.01$, $df=19$) than the higher mileage drivers.
- **EXPERIENCE.** The average scores of the less experienced drivers were significantly higher ($p<0.01$, $df=19$) than the more experienced drivers.
- **GENDER.** The average scores of the males were significantly higher ($p<0.05$, $df=19$) than females.
- **MAP.** The average scores of the good map-readers were significantly higher ($p<0.01$, $df=19$) than the bad map-readers.

3.2 Questionnaire Survey Results

The questions used can be categorised into three groups: Usefulness, Problems, and Understanding. (Signs 1, 7, 12 and 17 were not assessed, since 1 was an existing motorway sign (used within the simulator scenarios as a base case) and the others were flashing variants of signs 14, 5 and 3, respectively).

Usefulness

The perceived Usefulness of each sign design was rated on a scale of 1 to 10 (1 the lowest and 10 the highest). The average scores for each sign are shown in Figure 5a.

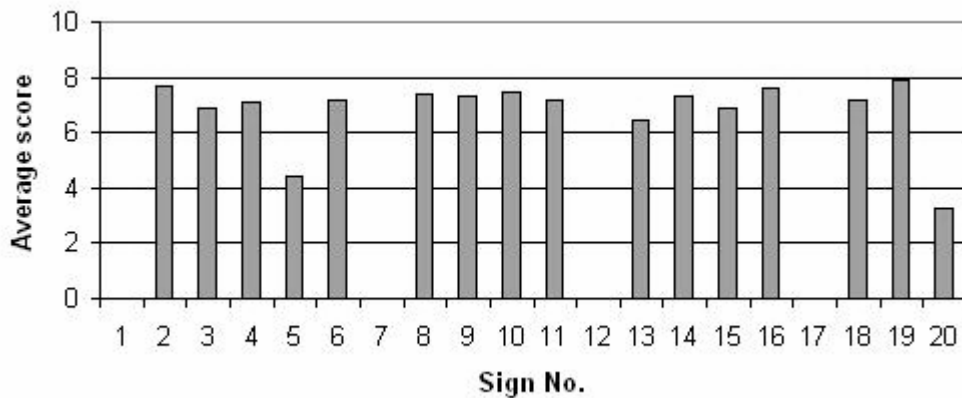


Figure 5a. Usefulness of Sign Designs

Signs 5 (and 12) and 20 are ranked substantially lower than the other signs, with mean scores of 4.43 and 3.25, respectively. In addition, the median scores were of similar size (4 and 3, respectively). These particular signs each consisted of (approximately) 18 information units, making them among the most detailed of all the sign designs. Signs perceived to be the most useful were 19, 2 and 16 in that order. However, there were only marginal differences in the mean scores of the other sign designs, with a range of 6.47 to 7.88. All sign designs received at least one maximum score of 10.

- VIEWING TIME. The average scores generated from the two sets of viewing times were not significantly different ($p=0.183$, $df=15$).
- TOIQ. The subjects who were asked 'before' questions rated the Usefulness of the signs significantly higher ($p<0.01$, $df=15$).
- AGE. The younger drivers rated the signs significantly higher than the older group ($p<0.01$, $df=15$).
- MILEAGE. The lower mileage drivers rated the signs significantly higher ($p<0.01$, $df=15$) than the higher mileage drivers
- EXPERIENCE. Inexperienced drivers rated the signs significantly higher than the experienced ($p<0.01$, $df=15$).
- GENDER. No evidence was found of any significant differences in responses between males and females ($p=0.429$, $df=15$).
- MAP. No significant differences were found according to map reading ability ($p=0.637$, $df=15$).

Problems

For each sign design, the subjects were asked to identify Problems and the average scores for each sign are shown in Figure 5b.

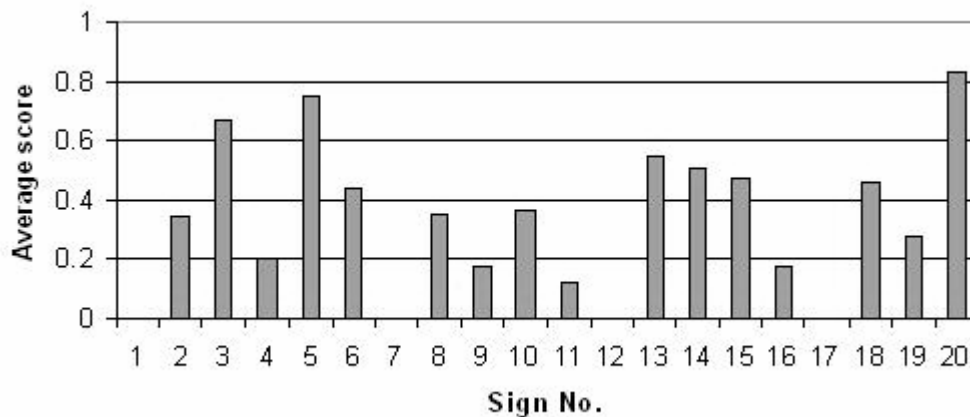


Figure 5b. Problems with Sign Designs

A higher score means that more problems were experienced with the sign design. It can be seen that the signs giving the most problems were designs 20, 5 and 3. Signs giving the least problems were 11, 9, 16 and 4.

- VIEWING TIME. It was found that those subjects who had been allotted a viewing time of 6 seconds in the experiment were significantly more likely ($p < 0.01$, $df = 15$) to find a problem with the sign information.
- TOIQ. The 'after' subjects were significantly more likely ($p < 0.01$, $df = 15$) to experience problems.
- AGE. There was no evidence of any significant difference ($p = 0.139$, $df = 15$) between the two age groups.
- MILEAGE. The higher mileage drivers were significantly more likely ($p < 0.05$, $df = 15$) to find a problem.
- EXPERIENCE. There was no evidence of any significant difference ($p = 0.114$, $df = 15$) between the two groups.
- GENDER. No evidence of any significant differences in responses was found between males and females ($p = 0.753$, $df = 15$).
- MAP. No significant differences were found ($p = 0.126$, respectively, $df = 15$).

Understanding

Written questions were also used to assess each subject's Understanding of the information contained in each sign design. The average scores are shown in Figure 5c.

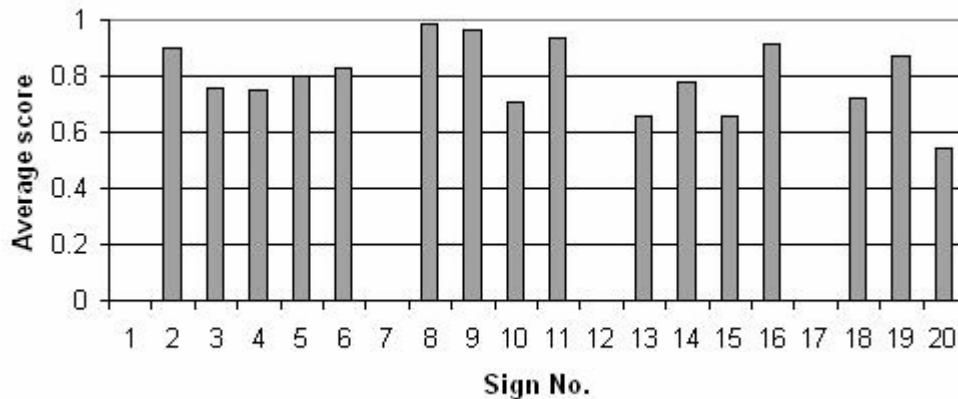


Figure 5c. Understanding of Sign Designs

A higher average score means that the sign design can generally be regarded as being more understandable although the difficulty level of the questions was not consistent for each sign design. The sign designs scoring highest were signs 8, 9 and 11. Those signs scoring lowest were 20, 13 and 15.

- VIEWING TIME. The average scores generated from the two sets of viewing times were not significantly different ($p=0.915$, $df=15$).
- TOIQ. There was no significant difference ($p=0.648$, $df=15$) between the two groups.
- AGE. The older drivers scored significantly higher ($p<0.05$, $df=15$).
- MILEAGE. There was no evidence of any significant difference ($p=0.193$, $df=15$) between the two mileage groups.
- EXPERIENCE. The more experienced drivers were significantly more likely ($p<0.05$, $df=15$) to understand the sign.
- GENDER. No evidence of any significant differences in responses between males and females ($p=0.100$, $df=15$) was found.
- MAP. The average scores of the good map-readers were significantly higher ($p<0.01$, $df=15$).

3.3 Summary

Viewing time would only seem to have an effect on the number/degree of Problems recorded, with more being apparent for viewing times of 6 seconds, indicating that optimal response accuracy had been reached by 4 seconds, i.e. a point at which the maximum amount of information could be extracted from a sign. However, viewing time would not be expected to affect any of the questionnaire dependant variables as all subjects were given the same exposure to the paper questions after the simulator runs. This is generally true, with the exception of Problems, where those with longer exposure times had more of a chance to experience problems with the signs in the tests, thereby subconsciously biasing post-experimental responses. Those asked questions before the signs appeared recorded a better accuracy in sign comprehension in the interview questions. In essence they were 'primed' as to which piece of information to extract from each sign. However, they returned higher

Usefulness scores and lower Problem scores, which again would appear surprising. This could be a subconscious bias, with 'positive' memories of finding signs easier to read than the after group, resulting in a more optimistic set of responses. The exception to this is that a higher response was not demonstrated for the Understanding variable. This response is governed by direct objective questioning, potentially bypassing any subconscious bias.

Younger or less experienced participants rated higher in terms of Accuracy and Usefulness, but older/more experienced drivers rated better in terms of Understanding. Lower Mileage participants rated higher on Accuracy and Usefulness but worse in terms of Problems, while Good map readers displayed a higher Accuracy and better Understanding. To an extent these findings may be expected as those less used to driving are likely to rate anything that aids the driving process as useful and are likely to encounter more problems with the assimilation/interpretation of information. However, an apparent contradiction is that those who have driven less observed the signs in the interviews with a greater Accuracy, potentially an artefact of the novelty of participating in the experiment.

Additionally a correlation analysis between dependant variables, revealed a number of strong relationships with the only pairwise comparison of the six relationships failing to reach the $p < 5\%$ level being that between Understanding and response Accuracy. Accuracy was found to increase with rated Usefulness and decrease with the Problem rating, while Problems were found to decrease as both Usefulness and understanding decreased.

4. Discussion

The research found that some sign designs were clearly more successful than others. For example Figure 6a shows a plot of Usefulness vs Response Accuracy, where signs toward the top right of the plot may be viewed as 'better' than those in the bottom left. It should again be emphasised that the research aim was not to estimate the effects of the sign on route choice diversion, but rather to test a subject's ability to take in and understand the GCDP designs. The potential effects of the signs on network loading have not been considered in the work described in this report, but have been considered elsewhere in a business case undertaken by Atkins Transport Systems. There are basic differences in the sign types and number of information units, which clearly influence the ratings of the signs in terms of understanding of the information and associated problems (for example Figure 6b which shows a clear inverse relationship between response accuracy and information units). Assuming that the information on a sign can be read and understood, it is intuitively likely that a sign with a greater quantity of information will result in more drivers reacting to the information.

Link-based Signs – 4, 9 and 11.

Signs 4 and 11 generally performed better than sign 9 and there is an additional financial argument for using signs 4 and 11 since existing motorway VMS could be used to display such information. However, some subjects found the use of the word 'congestion' ambiguous in sign 4, and did not understand whether 54 minutes referred to the delay or journey time. Therefore, sign 11 was recommended as the best sign option of this type.

Text Signs – 2, 6 and 16.

Sign 16 generally scored higher than signs 2 and 6, which implies that subjects found three lines of text harder to understand than a sign with only two. Another common problem was the description of a route using a text message. For instance, “M42/M6” was commonly misinterpreted as “From the M42 to the M6” rather than “the M42/M6 route”. Therefore, sign 16 was recommended as the best sign of this type.

Graphical Signs – 3, 7, 14, 15, 17 and 18.

Although six signs have been included within this type, they consist of essentially two different designs: a ‘two-colour’ design (signs 3, 15 and 17) and a ‘three-colour’ design (signs 7, 14 and 18), with the latter generally scoring higher. Therefore, it may be inferred that if a clear distinction can be shown between the three routes, the sign may be readily able to be interpreted and recalled.

In addition, the majority of subjects (some 75%) preferred the non-flashing version (sign 14) compared to the flashing version (sign 7). Sign 18 was a variant of sign 14, but orientated head-up to investigate if it was understood equally well when the direction of travel was southbound. A number of subjects found the orientation confusing, and a further area for research is to examine the usefulness of sign 18 being displayed north-up (i.e. with the white arrow being displayed in the top-left corner of the sign design). Therefore, sign 14 was recommended as this best sign type.

However, there are two further issues arising from the research that need to be resolved before a field trial should be undertaken. One relates to colour coding, with approximately three quarters of the subjects believing that the use of the green colour was simply to highlight the quickest route and was not intended to provide any information regarding the level of service of the route (i.e. it did not indicate whether the route was free-flowing or congested). The remainder believed that the green colour implied that traffic on the highlighted route was free-flowing. The second issue is the precise route related to the displayed journey time. Interpretations were split approximately equally between those believing that the calculation of the journey time started at the decision-point of the route (i.e. the M40/M42 interchange), and those who believed it began at the location of the sign. These differences could be significant, especially in congested conditions.

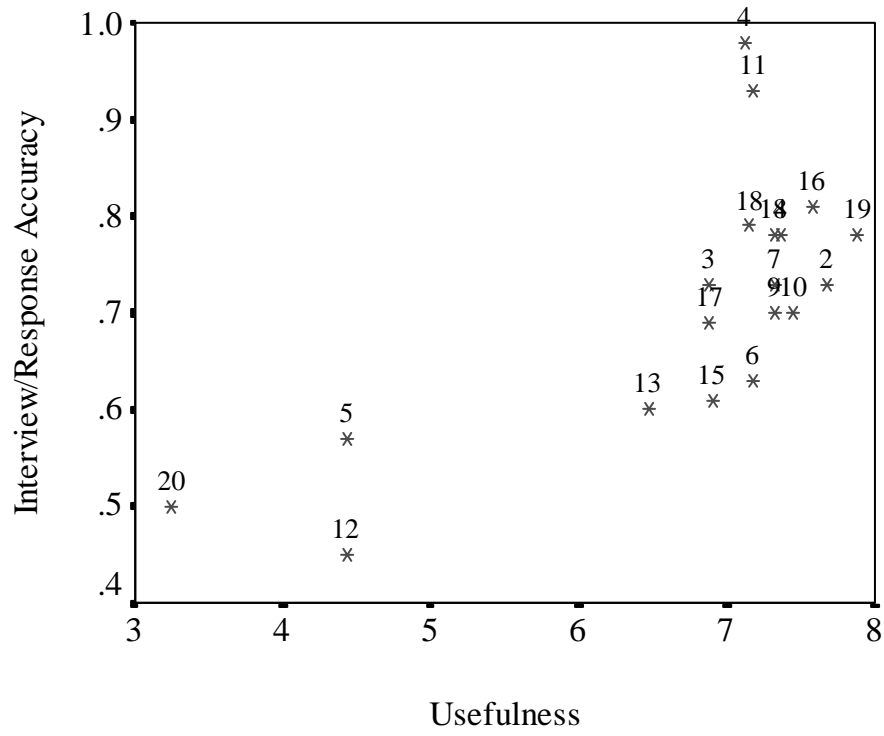


Figure 6a. Response Accuracy from Interview vs Usefulness Score by Sign

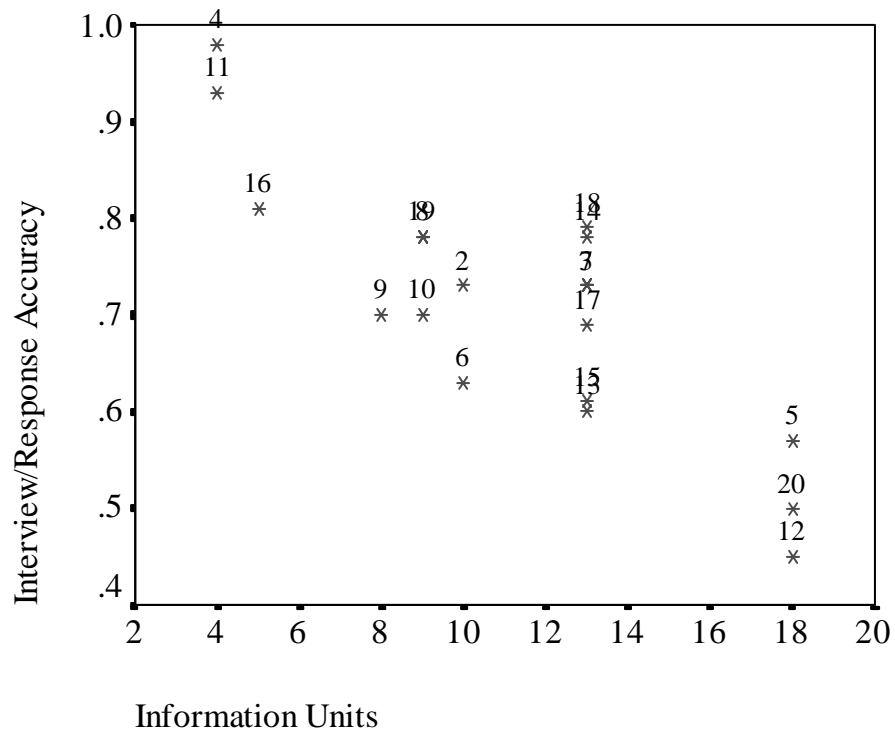


Figure 6b. Accuracy of Response vs Information Units by Sign

Graphical Segmentation Signs – 5, 12 and 20.

All three signs (5, 12 and 20) performed significantly worse than the others in all areas of the experiment and so it was concluded that these designs contained too much information to risk using them in an on-road trial. However, it may be that regular users, once familiar with the signs, would find them useful.

Lane/Junction-based Signs – 8, 10, 13 and 19.

Sign 13 caused the most problems for the subjects, with many finding it difficult to assimilate all the information and overly complicated. A potentially serious mistake with sign 10 was that the green arrow signified that this route was open and that the black arrow implied the route was closed. Signs 8 and 19 performed best, although colour coding the journey time is probably preferable. Sign 19 was recommended as the best sign of this type, although a few respondents noted that the green journey time display should be made more prominent.

5. Conclusions

The study focused on sign designs for the motorway network around Birmingham in the UK, and found that differing sign and user characteristics may lead to improved driver comprehension. For example drivers asked questions before seeing the signs (potentially a surrogate of familiarity with the network) are better able to deal with signs, while for most signs a view time of 4 seconds appears to be enough to allow a good understanding. Of the signs themselves it is difficult to undertake any clear prioritisation. However, Link based signs (4, 9 and 11) would seem to fare better than others, while an increase in the text present would seem to reduce user comprehension. Similarly although an increase in the number of colours present does increase comprehension a degree of confusion as to the meaning of the colours can arise.

It is acknowledged that the results of the study have only been presented for each individual sign. Consequently, the findings are somewhat difficult to interpret with various factors influencing the results. Other variables such as 'complexity' or 'amount of information' may have explained some of the differences found. However, the sign groups were not used in the analysis as our sponsors preferred a sign by sign analysis. In addition, such analyses were too time-consuming to be undertaken within this introductory, exploratory study, although there is a possibility that the data can be more fully explored in a subsequent more detailed study. The use of 'amount of information' as a variable, although tempting, would at this level be erroneous and the allocation of information units to a sign, although justified, is a subjective matter and a research field in itself.

Future research should cover areas such as harmonisation with similar signs already in use in Europe, the colour and size of the text, use of a variable title, colour coding of the routes, differentiation between the various routes, and the use of a symbol to indicate a blocked link. Three other areas need to be examined before any design recommendations may be implemented:

- i) Location of signs and their integration with existing signs, especially VMS. For example, the level of signing may need to be different at each location, but the range of text used

by all the signs could be examined to assess the level of priming information about route choice.

- ii) Users will be a mixture of regular drivers and irregular drivers who will be more unfamiliar with the network and route choice options. In addition, users will have varying driving abilities and reading times and driver reaction to the travel information on a GCDP will undoubtedly change as a consequence of their learning experience. (For example in Figure 7 it is possible to see that as the number of information units increases, the response accuracy worsens ($r^2 > 0.78$). The two lines show the separate sets of results obtained, depending on whether the interview questions were asked before or after the subject saw the sign (TOIQ). It can also be seen that the 'before' results for a sign with 10 information units equate approximately to the 'after' results for a sign with only four information units. This could imply that a driver familiar with the route options (one basing decisions on executing selective memory) can absorb about six information units more than an unfamiliar driver (one basing decisions on overall memory of a sign), before any loss in accuracy in understanding the information).
- iii) Impacts, where the level of design detail influences the sign effectiveness. A complicated sign will be likely to enable route choice, but may have safety implications. This must be balanced against a more basic sign design, with less detailed information and fewer route choice changes.

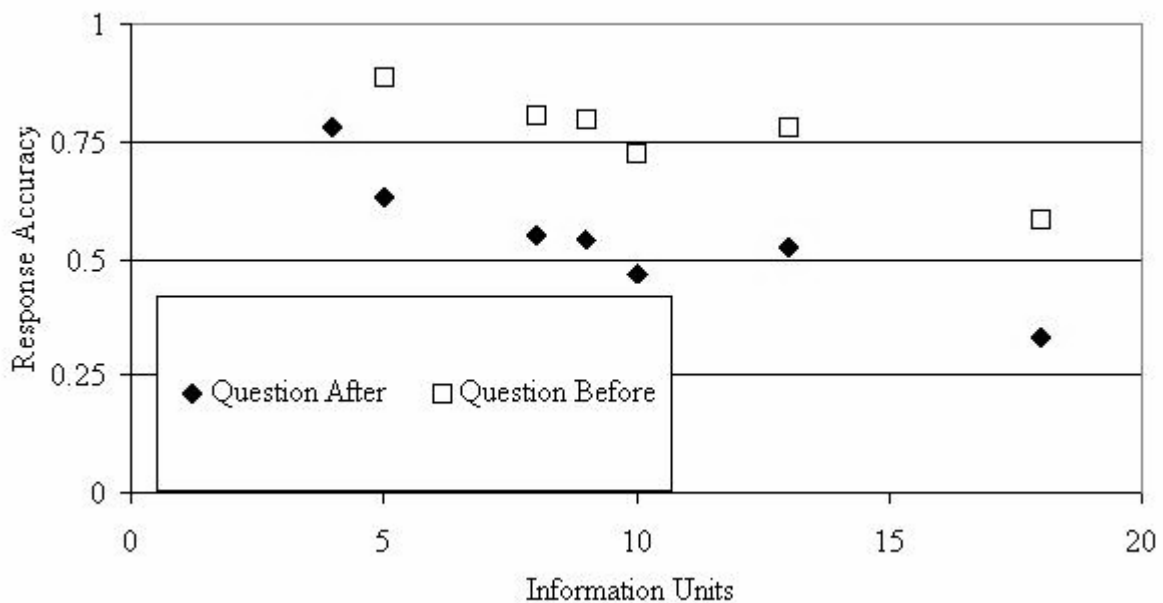


Figure 7. Response Accuracy vs Information Units

Acknowledgement

This research was undertaken as part of a contract awarded to Atkins Transport Systems by the Highways Agency, and their support is gratefully acknowledged. The authors are also grateful to Mr Ben Waterson of TRG for his helpful comments regarding statistical analysis.

References

- Alkim, T; van der Mede, PHJ; Janssen, WH (2000). Graphical Route Information on Variable Message Signs: *Proceedings of the IEE Conference, Road Transport Information and Control*, Conference Publication No. 472 © IEE 2000, London.
- Alkim, T; Schenk, B (2001). Graphical Route Information: *Proceedings of the 8th World Congress on Intelligent Transport Systems*, Sydney, 30 September – 4 October.
- Antin, JR; Dingus, TA; Hulse, MC; Wierwille, WW (1990). An Evaluation of the Effectiveness and Efficiency of an Automobile Moving-Map Navigational Display. *International Journal of Man-Machine Studies*, 33, pp 581-594.
- Ayama, M; Hasegawa, H; Kawaguchi, M; Ihata, N; Ikegami, M; Kasuga, M (2002). A Study to Measure Spare Capacity of Driver's Attention Payable to Cognitive Subtask. *Proceedings of the IEEE 5th International Conference on Intelligent Transportation Systems*, Singapore, 3 – 6 September.
- Bonsall, P; Firmin, P; Anderson, M; Palmer, I; Balmforth, P (1997). Validating the Results of a Route Choice Simulator, *Transportation Research C*, 5 (6), pp 371-387.
- Brockman, RJ (1991). The Unbearable Distraction of Colour. *IEEE Transactions of Professional Communication*, 34 (3), pp 153-159.
- CONVERGE Project (1996). *Guidebook for Assessment of Transport Telematics Applications*. TR 1101. DVQ5.1.
- Dingus, TA; Hulse, MC (1993). Some Human Factors Design Issues and Recommendations for Automobile Navigation Information Systems. *Transportation Research C*, 1 (2), pp 119-131.
- Dudek, CL (1979). Human Factors Considerations for In-vehicle Route Guidance. In *Transportation Research Record*, 737, pp 104-107. National Research Council, Washington, D.C., 1979.
- Dudek, CL; Huchingson, RD (1986). *Manual on Real-Time Motorist Information Displays*. Report No. FHWA-IP-86-16. FHWA, U.S. Department of Transportation, Washington, D.C.
- Dudek, CL; Ullman, GL (2002). Flashing Messages, Flashing Lines, and Alternating One Line on Changeable Message Signs. In *Transportation Research Record*, 1803, pp 94-101. National Research Council, Washington, D.C., 2002.
- Hall, RD; McDonald, M; Rutley, KS (1991). *An Experiment to Assess the Reading Time of Direction Signs*. *Vision in Vehicles –III*. A.G. Gale et al (Editors). Elsevier Science Publishers B.V. (North-Holland), ISBN 0 444 88601 X, pp 333-350.

Hanowski, RJ; Kantowitz, BH (1998). Driver Memory Retention of In-Vehicle Information System Messages. In *Transportation Research Record*, 1573, National Research Council, Washington, D.C., 1998, pp 8-16.

Ihata, N; Ikegami, M; Kawaguchi, M; Ihata, Hasegawa, H; Ayama, M; Kasuga, M (2002). Reaction Time of the Secondary Task while Driving in Various Situations. *Proceedings of the IEEE 5th International Conference on Intelligent Transportation Systems*, Singapore, 3 – 6 September.

Kantowitz, BH (1992). Heavy Vehicle Driver Workload Assessment: Lessons from Aviation. *Proceedings of the Human Factors Society 35th Annual Meeting*, pp 1113-1117. Santa Monica, CA: Human Factors Society.

Kloot, G (1999). Melbourne's Arterial Travel Time System. *Proceedings of the 6th World Congress on Intelligent Transport Systems*, Toronto, 11 – 14 November.

Kosnik, WD; Sekuler, R; Kline, DW (1990). Self-reported Visual Problems of Older Drivers. *Human Factors*, 32(5), pp 597-608.

Koutsopoulos, HN; Lotan, T; Yang, Q (1994). A Driving Simulator and its Application for Modelling Route Choice in the Presence of Information. *Transportation Research C*, 2(2), pp 97–107.

Lotan, T (1997). Effects of Familiarity on Route Choice Behaviour in the Presence of Information, *Transportation Research C*, 5(3/4), pp 225-243.

Schönfeld, G; Reischl, A; Tsavachidis, M (2000). Dynamic Driver Information Goes Graphical – A New Quality in Urban Traffic Information. *Proceedings of the 7th World Congress on Intelligent Transport Systems*, Turin, 6 – 9 November.

STISIM Driving Simulator. <http://www.systemstech.com/stidrsm1.htm>. Accessed 20/10/03.

European Perspectives

New proposal for sustainable urban transport plans across Europe

Dominic Stead
OTB Research Institute for Housing, Mobility and Urban Studies
Delft University of Technology
Delft
The Netherlands
email: d.stead@otb.tudelft.nl

EJTIR, 4, no. 4 (2004), pp. 437-439

Received: February 2005

Accepted: February 2005

“Urban transport systems are critical elements of the urban fabric. They ensure that people have access to goods, services, employment and recreation opportunities, that freight circulates efficiently and they enable local economies to flourish. However, if the high density of buildings is the first defining characteristic of towns and cities, then high volumes of traffic is now the second. Traffic has significant impacts on the environment and on the health of urban citizens, as well as on the overall quality of life in towns. Rising congestion levels are hampering mobility, with increasing costs for the economy (0.5% of Community GDP for road traffic congestion, rising to 1% by 2010).”

So begins one of the sections in the recently published Communication from the European Commission entitled ‘Towards a Thematic Strategy on the Urban Environment’ (CEC, 2004). The communication calls for new measures to deal with the rising volumes of traffic in addition to the various current initiatives such as cleaner fuels, intelligent traffic management systems, emission standards and vehicle safety. Improvements from these current initiatives need to be set against the predicted increase in traffic and congestion in urban areas, the Communication states. Between 1995 and 2030, the number of kilometres travelled in urban areas is predicted to increase by 40% (CEC, 2004:17). The European car fleet has trebled in the last 30 years, and 3 million cars a year are added each year (ibid.). Particularly sharp rises in car ownership and use are likely in many of the new EU countries. Vehicle engines are cleaner than before but the growth in the ownership and the use of the car will make it increasingly difficult to reduce the total environmental impact of the car fleet in the future. Moreover, as the Communication recognises, even with clean vehicles, congestion ‘still has high economic costs’ (CEC, 2004:17). As the White Paper on European

Transport Policy highlighted in 2001 ‘the big problem that urban authorities will have to resolve, sooner than might be thought, is that of traffic management, and in particular the role of the private car in large urban centres’ (CEC, 2001:80).

Tackling transport demand in urban areas is of particular importance for a number of reasons, according to the 2004 Communication from the European Commission. Issues of air quality, noise, congestion and safety are still at unacceptable levels in many cities despite actions taken to tackle emissions, manage traffic and improve safety. Increases in transport demand threaten to worsen air quality, noise, congestion and safety, reduce the quality of life in cities and increase development pressures on peri-urban areas. There are various types of measures, instruments and policies that can be used to help to tackle transport demand. Technology of various types (information and communication technology for example) and pricing of transport and infrastructure can make an important contribution as well as regulations such as parking and land-use planning controls.

As a way of tackling transport demand in urban areas, the 2004 urban environment thematic strategy document puts forward the proposal that the capital cities of Member States, as well as towns and cities with more than 100,000 inhabitants, should prepare, adopt and implement a sustainable urban transport plan (CEC, 2004:17). Such plans would therefore be required in approximately 500 towns and cities across the EU25. According to the Communication, the sustainable urban transport plan would cover the whole urban area, would seek to reduce the negative impacts of transport and tackle the rising volumes of traffic and congestion, and would link to regional and national plans and strategies. It would cover all modes of transport and seek to change the modal split in favour of more efficient transport modes such as public transport, cycling and walking. One of its basic objectives would be to create a more environmentally efficient transport system that serves all of the town’s citizens. The link with land-use would be an essential component. The plan would be linked with the town or city’s overall plans and objectives for environmental, economic and social development (CEC, 2004:18). To complement and support these local plans, the Communication proposes that all Member States will also be encouraged to seek to internalise the external costs of transport through measures such as taxation, road user charging and licence fees, and to undertake evaluations after the introduction of new measures in order to improve understanding about the effects on the sustainability of the urban transport system.

According to the Communication, such plans would help around 500 towns and cities in the EU to meet the requirements of EU Directives on air quality and noise assessment and management, and would contribute to meeting the Kyoto agreement targets. The plans would play a particularly important role to maintain the existing levels of use of more efficient transport modes in the new EU countries, the Communication asserts, since a much larger proportion of the public uses public transport systems in these countries compared to the EU average, although this use is falling and car ownership is rapidly rising.

The urban environment thematic strategy document recognises that something similar to sustainable urban transport plans can already be found in some EU countries such as Finland, France, Italy, the Netherlands and the UK (CEC, 2004:17). It is therefore conceivable that the impacts may not be great for these Member States if the proposal is implemented. The

current Local Transport Plans produced in England and Wales or the municipal traffic and transport plans (*Gemeentelijke Verkeers- en Vervoersplannen*) produced in the Netherlands or the urban movement plans (*plans de déplacements urbain*) produced in France could, for example, be sufficient to satisfy the requirements of a sustainable urban transport plan. This is, however, speculation as the situation regarding the proposal for sustainable urban transport plans is still currently under consideration within the European Commission. The 2004 urban environment thematic strategy document reports that the proposal for sustainable urban transport plans will be the subject of further consultations.

According to Eurocities (a network of major European cities), many cities in Europe have already developed their own plans and strategies with regard to sustainable development, including environmental management and urban transport, and most are willing to accept that this should be a requirement for all large cities in the European Union. However, a number of cities are also concerned that the environmental focus of the proposed plans should not detract from the need to ensure a more integrated approach, bringing together environment, transport, health, social, employment and economic policies. Eurocities is therefore urging that the plans should become more wide-ranging, covering all aspects of sustainable urban management. In the UK, the Local Government Association, which represents local authorities in England and Wales, has expressed its opposition to the proposal, stating that the Local Transport Plan process in England and Wales is delivering results and additional requirements could result in ‘an added layer of complexity that could detract from the results already being realised by local authorities’ (LGA, 2004:4).

It is currently unclear how the proposal for sustainable urban transport plans in European towns and cities might affect different EU countries if it is indeed implemented. It is possible to speculate that it may attempt to use the current system already in place in countries such as Finland, France, Italy, the Netherlands and the UK and give greater emphasis to environmental issues and more prominence to the link between transport and land-use planning. More information concerning the proposal for sustainable urban transport plans and the implications for the current system of transport planning in EU countries will emerge within a year since work on the Commission’s Thematic Strategy on the Urban Environment is currently in progress (and due to be published in the summer of 2005), and the European Union’s Sustainable Development Strategy is in the process of being reviewed.

References

Commission of the European Communities – CEC (2001). *White Paper. European transport policy for 2020: time to decide [COM(2001)370]*. Office for Official Publications of the European Communities, Luxembourg.

Commission of the European Communities – CEC (2004). *Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. Towards a thematic strategy on the urban environment [COM(2004)60]*. Office for Official Publications of the European Communities, Luxembourg.

Local Government Association – LGA (2004). *Response from the Local Government Association to Communication 'Towards a thematic strategy on the urban environment'*. LGA, London.