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SOME THOUGHTS ON THE WAYS IN WHICH DRIVERS CHOOSE & STORE INFORMATION ABOUT ROUTES & HOW NEW INFORMATION MIGHT BE PROCESSED BY THEM

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1. INTRODUCTION

This note represents a mind dump of my thoughts on this topic as at mid April 1992, it does not purport to be a finished paper and leaves several issues unanswered.

I was stimulated to put my thoughts on paper after reading the first draft of Nicholas Gotts' digest of his DPhil Thesis (Gotts, 1992). I was particularly keen to set down my thoughts on strategic planning and tactical adjustment as elements of the route choice process and to further develop the theme of different forms of mental maps since this is a topic in which I first dabbled within my own, undergraduate, dissertation.

The theme of the note was intended to be: what implications does the way in which a driver stores information about the road system have for the design, content and impact of route guidance and information systems? - but, as is often the case with mind dumps, the original theme spawned a variety of sub issues.

2. HOW DO DRIVERS CHOOSE ROUTES?

It is perhaps useful if I here set out my view on how drivers choose routes, since this may help the reader to interpret what I have written in the subsequent sections.

I maintain that route choice criteria vary according to the purpose of the journey and will depend on the driver's familiarity with the network. I also suggest that individual drivers will have different preferences and that these may vary from occasion to occasion even if the journey purpose and familiarity are unchanged.

Journey purpose is likely to affect route choice criteria via the mood of the driver, the general time pressures, and the importance of arriving by a particular time.

Network familiarity may affect criteria via the level of information available to the driver and the probability with which any given objective could be expected to be met (if you are in a network which is entirely unfamiliar to you, you may be quite satisfied if you reach your destination without major mishap - questions of minimising time or avoiding queues might be irrelevant niceties).

An individual driver may, other things being equal, have a predilection to use fast roads, to avoid dangerous junctions, to choose the scenic route and so on. These predilections may change from day to day.

I maintain that route choice has two main components; a strategic plan made before departure and tactical adjustments made en route.

The strategic plan will be based on information available prior to departure (in the case of repeat journeys this would probably be dominated by experience gained on previous journeys but would otherwise rely on information from maps, previous journeys to adjacent locations, general knowledge, habit and so forth). The strategic plan may include sufficient detail to take the driver right to the destination or may be sufficient only to begin the journey (an example of the latter might involve a plan to use the motorway to get to the correct part of the country, to use local signposts to reach the town in question and then to use a local map to find the precise address).

As in the above example, I think it quite possible that a strategic plan might specify methods of finding a route (follow signposts, consult a local map) rather than indicating

an actual route to be followed. I also suggest that a strategic plan might contain options ("take A1 or M1 depending on traffic conditions experienced on M25" or "use local map unless the destination is signposted").

Driver route choice is of course, a fairly well researched topic and important work has been produced by several authors over the last two and a half decades. I have reviewed this work elsewhere (Bonsall, 1992) but should mention here Wachs (1967), Benshoof (1970), Heathington et al. (1971), Ueberschaer (1971), Huchingson et al. (1977), Lunn (1978), Outram and Thompson (1978), Stephenson (1981), Ben Akiva et al. (1984), Bonsall and May (1986), King (1988), Al Deek et al. (1989) and Bonsall and Parry (1990).

3. MODELS OF REALITY

Drivers might store information/expectations and knowledge relevant to the journeys they are about to make in various ways. These might include: spatially organised information (which I will term "maps") pictorial information (which I will term "image libraries"), and miscellaneous information. Note that, in using the terms "maps" and "image libraries" I do not mean to imply that the physical properties of these media are present.

"Map like" representations would probably be "distorted" (relative to ecluidean geometry) to a greater or lesser extent. This distortion might be random or might reflect factors such as relative travel times or frequency of use of different parts of the system. The "maps" could be of various kinds, including:

- ideas about relative locations in space (at their least sophisticated these might simply be ideas about the directions in which specified locations are relative to one or more anchor points. More sophisticated models would include some idea of relative distances and might even include some idea of the locations' positions in two dimensional coordinate space).

- ideas about paths (sets of ordered locations with or without information about the absolute or relative spacing of the locations).

- ideas about local networks (interconnections between sets of locations).

- hybrids - typical "maps" might include information of various types, with some locations seen in local networks, some in paths, some as isolated points. The relationships between the local networks, paths and points might be seen via some sort of higher level framework which might itself be ordered as a network or path.

Image libraries might contain images relating to individual locations, paths or local networks or to abstract location categories such as city centres, one-way streets or motorways, built up from experience of that type of location. They might be "still" or "moving" images and would probably emphasise qualitative information (eg aesthetic attributes and busyness) rather than topology.

Miscellaneous information might be of various kinds including, for example, impressions as to the traffic conditions that might be expected along certain routes. Isolated aspatial "facts" such as the speed limit on dual carriageways or the cycle time on traffic lights should obviously be included under this heading.

The usefulness of each of the three forms of storage is, of course, very dependent on the way in which they can be accessed. Some elements might be accessed at will but others might only be triggered by visiting the location concerned (this might be particularly true

of items in an image library). This distinction will, of course, crucially affect the usefulness of the information for the preplanning and en-route modification of routings.

It is, of course, likely that different drivers will store information in different ways and that individual drivers will store different information in different ways. Nevertheless, there may be systematic tendencies for certain types of information to be stored in certain ways.

4. THE EFFECT OF NEW INFORMATION

New information, whether derived from direct experience, reports from third parties or "public" information sources/systems, will either:

confirm existing knowledge,
extend existing knowledge, or
conflict with it.

It is useful to consider the implications of each of these separately.

If "new" information simply confirms previous knowledge then it might be expected to have no discernable effect on behaviour. If, however, we assume that "previous knowledge" about something is not fixed but variable (in the sense that it evolves) then "confirmation" may affect that evolution such that a piece of information is given more weight or might be retained for longer than it might otherwise have been. Thus for example, a driver might believe that a given route is subject to congestion and traffic broadcasts about delays on that route might reinforce this belief such that it becomes a major contributor to a decision to avoid that route where possible.

Given our non-fixed definition of previous knowledge, it is quite possible that confirmatory information could result in a change in behaviour. For example if the driver is "reminded" about something he had temporarily "forgotten" or if confirmation of some fact which favours route B over route A is sufficient to tip the balance of favour towards B.

New information which extends previous knowledge without conflicting with it will generally be accepted at face value. However, the credibility of the source may determine whether or not the new information is relied on in high risk decision. Thus if a driver has been using route A in preference to a notoriously congested route B to reach his local airport but overhears a man in a pub say that, following completion of roadworks, B is now quicker than A, he may not think it worth the risk of taking B. Whereas if he hears a newsflash on his car radio about a serious accident on A he might decide to take B.

If new information conflicts with previous information/knowledge then the driver has to decide to what extent should "believe" the new information in preference to the old. The credibility of the source of the new information is clearly an important factor but so too will be the credibility of the "previous" information. Thus if new information (eg a press article) tells the driver that a notorious congestion spot on route B has been "solved" by a new junction layout the driver may conclude that it is worth trying route B. If the press article were accompanied by photographs of free flowing traffic and testimonials by satisfied drivers then the new information might be particularly convincing. If, however the driver's colleague having used route B on the previous day, reported that the situation was as bad as ever, or today's broadcast traffic bulletin mentioned congestion on route B, or if a traffic jam appearing to originate at the supposedly improved junction was visible to the driver, then the credibility of the article might be cast into doubt.

Conflicts between "new" and "old" information might, in theory, be resolved "rationally" after due consideration of all relevant factors, but individuals are likely to adopt a number

of short cuts in this process. For example heuristics might be used which implicitly give higher credibility to certain types of information than to others, eg personal experience rather than indirect experience; visual evidence rather than verbal reports; recent evidence rather than old evidence; colleagues rather than "official" sources). These heuristics are likely to vary from individual to individual reflecting each one's attitudes, predilections, experience etc. In the light of this variety of approaches to conflict resolution it may or may not be possible to develop a useful model to predict probablistic outcomes.

Advice is a particularly interesting category of "information". It may be appropriate to treat it as factual information (the fact that a given route is advised by such and such system or individual) but it may be necessary to recognise its status as a kind of higher level "knowledge" having been processed by some system or individual. As with other forms of information advice may serve to confirm, extend or conflict with previous information and, in deciding whether to act on it, the individual will consider the credibility of its source, the extent to which it is corroborated by or in conflict with other information and the risks involved in accepting or rejecting it.

5. HOW MIGHT THE DIFFERENT MODES OF STORAGE AFFECT DRIVERS' REACTIONS TO ROUTE GUIDANCE AND INFORMATION?

5.1 "Map Like" Representations

Provided that a driver's mental map contains an idea of relative locations in space via a directional sense (eg "my destination is in that direction") then he would have a basis for assessing the credibility of directional advice and for understanding the possible importance of information relating to a specified direction (eg "congestion ahead"). If he can put labels on directions (eg North, South, East, West) then he might be able to process information using similar labels ("head North for 3 miles").

If a driver is used to travelling with no more then his mental compass, he may have become accustomed to finding that the "best" route is not always the most direct (because networks are discrete) and may be prepared to accept that, even if they conflict with his mental compass, other forms of guidance can have considerable value.

If a driver's mental map contains information about paths or local area networks then he will be well placed to assess the credibility of advice which relates to those paths or networks. (He might realise, for example, that an apparent diversion from a straight line path is justified because it leads in due course to a faster road.) If his map has labels (eg road names or place names) then advice using those levels could be understandable to him.

5.2 Image Libraries

If a driver is only able to "remember" images of places when he sees them then he will find them of little use in route finding - except as confirmation that he has visited such and such location at least once before. If, however, the image leads to a recall of additional information (eg "last time I was here I turned left by the telephone kiosk" or "when I went down there I met a bad traffic jam") then it obviously begins to have wider value.

Guidance which mentions, or recommends, a location of which the driver can conjure up an image will mean more to him than that which does not. Thus reaction to the new information will be coloured by whether or not he can picture the locations mentioned and

by whether the "picture" contains information that would lead him to wish to use or avoid that location. For example advice to use a specific motorway might be favourably received if the driver's "picture" of that motorway (or motorways in general) is generally positive whereas it might be rejected if the driver at once pictures hazardous driving conditions or nose-to-tail traffic.

5.3 Miscellaneous Information

It can be argued that information which is not "map like" and is not stored as series of images will be simpler to update. The argument is that maps and images involve specific linkages between individual "facts" and so it is rarely possible simply to replace one piece of information by another - the new information may force a reconsideration of linkages and relationships.

If this is so then it might follow that guidance and information that falls into a "miscellaneous information" category might be more readily absorbed than that which implies some updating of the driver's mental maps or image library. On the other hand, given the absence of a formal structure to this kind of data it may well be that, even though it is fairly readily "absorbed", unless its implications for route choice are clear (eg as in a direct instruction to turn left or to follow such and such road) they might be missed. For example; the "fact" that there has been a serious accident on the A660 two miles NW of Leeds may be absorbed by a driver during a traffic newsflash on his car radio but may not be translated by him into the advisability of avoiding Headingley if he does not associate the A660 which Headingley. To give another example: a driver could understand that the speed limit on motorways had been changed but might not appreciate the implications that this would have for the choice between a motorway and a non-motorway route to a given destination.

6. HOW MIGHT THE PRESENTATION OF GUIDANCE AND INFORMATION AFFECT ITS ABSORBTION BY DRIVERS?

Various models of presentation have been proposed and tested. Among the most significant, in the current context, are:

- "real time" instructions relating to a prespecified destination
  these may be:
  - verbal (eg "turn left")
  - written (eg "turn left")
  - pictograms (eg ←|)

- "advance" instructions relating to prespecified destination
  these may be written or verbal and may relate to:
  - network topology (eg "first left, second left after 1/2 mile")
  - landmarks (eg "left at the big pub then right at the war memorial")
  - named locations (eg "left into High Street then right into Church Street")

- map displays of the local network possibly with:
  - current position of vehicle marked
  - congested routes highlighted
  - a recommended route highlighted

- advisory directions for general or particular destinations
  these may be:
  - broadcast verbal

  - static roadsigns
  - variable message roadsigns
  - spoken

- "factual" information about network conditions (eg roadworks, accidents, congestion)
  these may be:
  - broadcast verbal
  - broadcast images (eg in the context of a news item)
  - text
  - spoken
  - annotated map

It seems intuitively reasonable to expect that a driver's responses will vary depending on the drivers sensory and cognitive skills, his level of prior knowledge and the way in which he has stored that knowledge. Obvious examples of mismatches include:

- audio information provided to deaf people
- text information provided in the wrong language
- use of colour codes undistinguishable by colour-blind people
- directions to a destination which is not relevant to the driver
- reference to landmarks unknown to the driver
- use of road names unknown to the driver
- use of compass directions if the driver has no compass nor innate sense of direction
- use of "left" and "right" if the driver is wont to mix these up
- presentation via maps if the driver "cannot understand" maps.

Generally speaking, and notwithstanding the problems outlined above, one would expect the "best" results if the new information is in the same mode as any prior information, since this will generally facilitate its absorbtion. (On the other hand if the provider of the new information is aware that it may initially conflict with prior information might it perhaps be better to use an alternative mode which makes the conflict less obvious?) It may be, however, that some modes of presentation are inherently more "powerful" than others. For example a real-time image of traffic conditions might be a very persuasive method of informing drivers about conditions ahead since it would carry the credibility which comes from having seen something "with ones own eyes". Variable message signs, on the other hand, currently suffer from low credibility due to the fact that many drivers have experienced situations when they warn of non-existent hazards while failing to warn of real ones.

7. DOES ANY OF THIS HAVE IMPLICATIONS FOR THE DESIGN OF GUIDANCE INFORMATION SYSTEMS?

I have suggested above that certain forms of presentation may be inherently more "powerful" than others. Other things being equal, these would be the ones to use. However, there are various reasons why this approach may be inappropriate.

Firstly cost/practicality; it may simply not be possible economically to provide the information on the desired format. (real time in-vehicle video images of congestion ahead might obviously fall at this hurdle).

Secondly safety; different types of presentation obviously put different demands on the driver's attention (compare audio instructions with a text message or map display). The implications that this has for safety are clear and fairly well researched. (See for

example; Stephens, 1990; Godthelp and op de Beek, 1991; Walker et al., 1991; Parkes et al., 1991.) It may be that safety requirements effectively constrain in-vehicle and roadside presentations to a subset of the list outlined in the previous section. Regulations forbidding users to consult certain types of display while driving will not be effective unless those displays are physically unavailable while the vehicle is in motion and even then stationary vehicles (stopped so that the driver can consult his in-vehicle display) might themselves constitute a hazard.

Thirdly the range of requirements; a recurring theme of preceeding sections of this paper has been that different drivers have different perceptual and cognitive abilities and predispositions, different attitudes and preferences and that these may vary, even for one driver, from one journey to another. It follows that the optimal form of information and guidance will vary from one driver to another and will depend on the prevailing circumstances. It may be that designs can be produced which use a sufficient variety of presentations (eg turning instructions via pictograms backed up by audio messages and text descriptions of the reasons) to cater for most circumstances or that market niches exist for a range of alternative designs.

Another aspect of design which is rather more straightforward relates to the use of labels; it is clearly important to ensure that the location names and road names used in the provision of guidance or information are likely to be familiar and appropriately precise for the specific circumstances in which they are employed. A vocabulary of labels could be set up after appropriate market research - it might or might not be necessary to examine the relevant vocabularies of drivers requiring different types of information (eg people wanting advance verbal or text information about the location of current congestion points might have a more extensive vocabulary of location names than someone wanting only directional advice).

8. WHAT IMPLICATIONS DOES THIS HAVE FOR MODELLING/PREDICTION OF ROUTE CHOICE AND OF REACTIONS TO GUIDANCE/INFORMATION?

Models are necessary for the preimplementation evaluation of route guidance/information system, for the design of control strategies and for the representation of route choices without guidance. I have argued elsewhere (Bonsall 1991, 1992) that most existing models are deficient as representations of route choice but I do not mean to suggest that a model need necessarily represent route choice processes in great detail; if they can predict route choices tolerably accurately then that may be good enough for most practical purposes.

The minimum implication of the discussions in this note is that in order to reduce error, it may be appropriate to categorise drivers according to variables which might reflect the way in which they store and access information. Further thought and reflection is needed before forming a judgement as to whether any more radical restructuring of route choice models is advisable.

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