The Driver as an Active Learner: Customising Real Time Traveller Information

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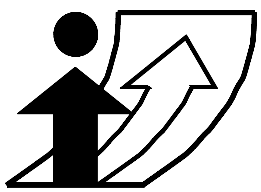

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The Driver as an Active Learner: Customising Real Time Traveller Information

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Abstract

While traveller information services deliver increasingly sophisticated incident reports, journey times and other such information, driver response has remained lukewarm. We suggest that the problem lies in understanding the driver rather than improving the content. This paper reports that drivers principally learn from their experiences and addresses fundamental questions arising from an Australian study identifying how drivers learn to apply available information. Preliminary data from the study suggests that commuter drivers travelling a new route for the first time display no more expertise than novices. When presented with dynamic, customised traveller information, the study suggests that commuter drivers enter a learning curve affected by previous experience and immediate need. Design of an effective traveller information system, it is argued, necessitates the targeted provision of information, sensitive to this evolving driver capacity.

Keywords

Traveller information systems, adult learning, driver behaviour, commuter drivers, familiar drivers, data fusion.

Preferred citation

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1. Introduction

Drivers drive for a purpose: to go to work, to travel to social, recreational or business events, to meet the needs of the family. The strategy chosen by drivers to reach their destination is dependent on their accumulated experience, their current knowledge of the projected journey and the resources and information they have before them. As in every real life situation, drivers never have complete information and the system of roads and traffic they encounter is always, to a degree, random.

The development of modern information technology has made it possible to deliver customised and personalised information to drivers, when and where they want it. Emerging access to variable message signs, web cameras, web sites and mobile telephone messaging has made customisation to specific driver needs increasingly possible.

Of course, delivery channels to drivers require content and the technology push from many commercial service providers favours simple incident reports, journey times and related information to drivers. Since its inception, the response of drivers to this content has remained lukewarm.

"John Smith" or "Jane Doe" does not seem to be that interested in our traveller information. We suggest that the problem lies not with the content but in our failure to understand the driver.

Drivers have been shown to be good and bad, passive and aggressive, patient and impatient, knowledgeable and neophyte. The settings in which they require information are dependent on weather, time of day, congestion levels and driver stress at the time of travel. Additionally, information can be presented and delivered in a range of ways at a variety of points in the journey. The rate that drivers can learn, interpret and factor this new information into travel plans also varies. Some drivers learn quickly and want more specific detail, others are overwhelmed, lack the processing ability to utilise given information or, misinterpret based on previous patterning.

The issue of whether drivers want traveller information remains – as does the more commercially compelling question, what information would drivers want if they had a chance to choose?

This paper, however, addresses the revelation of some underlying questions related to how drivers learn to use available information and, as a result, determine what information is use-

ful to them. The study undertaken by the authors leads to an understanding of how drivers currently learn from their journeys, how that learning affects their processing of information and how, having learnt to process information, this learning changes their demands from a traveller information system.

This paper is in five sections. The literature review outlines current research in traveller information and introduces research that is applicable to drivers as adult learners applying traveller information. A brief third section outlines the background to the study and the techniques employed in research. Preliminary findings are then presented and practical considerations arising from these are considered in a closing section.

2. Literature Review

Models for the impact of traveller information are usually based on trying to understand the relationship between information and driver behaviour and the impacts on the road network (Emmerink and Nijkamp 1999, Rooney 1999). Through models, surveys, trials and pilots, research has shown that some drivers change behaviours, some don't, some change routes, some don't, some are willing to pay, some are not, some use the information, and others neither use nor even need it (Dia *et al* 2000, Mehndiratta *et al* 2000, Mahmassani and Liu 1999). Indeed, theoretical models build in factors, assumptions and sensitivities to account for what is essentially, minimal usage and compliance by drivers (for example see Luk & Chao 2001). One of the better summations of driver behaviour modelling is provided by Ben Akiva *et al* (2001),

> *"(commercial) applications require the development of reliable models of driver behaviour and, in particular, of their response to messages. An important aspect of this is the development of better models of the ways in which travellers form new perceptions from their recent experiences, the information they received and their earlier experiences. These efforts will benefit from advances in understanding of the psychological and cognitive processes involved in decision-making."*

Research into driver behaviour has categorised 'advanced' or familiar vs unfamiliar drivers, commuters vs non commuters, pre-trip vs en route information and habits, pressures and cognitive loads (Saricks *et al* 1999, Schofer *et al* 1999, Lappin 2000A & B, Katsikopoulos 2000, Redshaw 2001, Toppen 2002). Researchers have also found that drivers are confident in their ability and most are accomplished in the task of getting from one routine point to another (for example, Nakayama *et al* 1999). Adler and Blue (1998) and Stern (1999) suggest that the day to day variations in travel performance and maturing of driver attitudes and perceptions shape driver behaviour and influence travel decisions.

Recent Australian studies (Kim & Vandebona 1998, Dia *et al* 2000, Karl & Trayford 2000) have found that commuters in Sydney, Brisbane and Melbourne favour 'prescriptive, predictive and quantitative real-time' dynamic information over more static direction such as alternative routes. This finding is well supported in similar studies internationally (Yang *et al* 1998, Koo & Yim 1998, Uno *et al* 2000, Lind 2000).

The potential content of traveller information for drivers spans a wide spectrum from raw data to highly processed and customised predictions which are derived from a process of data fusion, combining data from various sources. Keever and Pol (2002) propose that there are four levels to data fusion and hence four generic types of traveller information.

- Level 1: Data object refinements: wherein data objects are refined into a consistent set of units and co-ordinates,
- Level 2: Situation refinements: wherein data is interpreted into meaning, given the content that the data comes from,
- Level 3: Expectations refinement: the current situation is extrapolated into the future to draw inferences about network conditions, traveller behaviour and opportunities for operational improvements; and,
- Level 4: Meta process refinements: in essence feedback loops, which monitor the data fusion process and identify, refine and allocate resources to achieve improvements to the overall process.

Keever and Pol (2002) found that many traveller information services provided Level 1 data, a few (2 or 3) provided Level 2 refinements, but none operated at Level 3 or 4.

Traveller information can now be customised to meet specific and individual demands. Trials conducted over the past three years have delivered dynamic and customised traveller information to drivers in Melbourne, Sydney, and Hong Kong (Karl *et al* 2000, Karl & Trayford 2001, Trayford & van Leersum 2002, Karl & Whitmore 2002). These trials presented drivers with a unique source of traveller information delivered via SMS (Short Message Service) before the trip and updated in the event of unexpected incidents that occurred after the pre-trip message transmission. The technology associated with aggregating data and information into a comprehensive model is now under patent (AU200167144, 2001). This study therefore presented an opportunity to analyse drivers after they had experienced such a dynamic information delivery program.

Lessons from Spatial Research

In the act of driving, drivers undergo a process through which they acquire information about their surroundings, which they encode and store before applying it to solve recognised trip problems. Their mental map becomes part of a unique spatial knowledge (Deakin 1997, Khattak and Khattak 1998, Jackson 1998, Adler 2001). Deakin (1997) identifies procedural, declarative and configurational descriptors for this spatial knowledge. She defines procedural knowledge as a series of decisions on how to get from A to B. Declarative knowledge incorporates landmarks, routes and areas. Configurational knowledge represents a comprehensive system of spatial knowledge that integrates procedural and declarative spatial knowledge.

Utilising equivalent terms, Stern and Leiser (1988) identify *landmark, route* and *survey* knowledge before proposing that drivers' overall spatial knowledge of a city, unless they are professional drivers, is relatively low. Most drivers, they observe, display little learning even after several years in a new place, while professional drivers continue to learn. Confirming our earlier findings, Jackson (1998) describes this learning process as cognitive mapping, and observes that drivers acquire, encode and store information about their surroundings for later use in solving spatial problems such as way finding. This has led researchers such as Adler (2001) and Stern and Leiser (1988) to conclude that drivers follow a learning curve, increasing their spatial knowledge and improving their expertise in way finding.

This paper accepts that research findings in the spatial knowledge field are integral in addressing issues of traveller information design and presentation. It argues, in fact, that drivers build up their *traffic* knowledge in the same manner as their spatial knowledge. Spatial knowledge, cognitive maps and mental models themselves have their origins in models commonly described in the literature on education. Increasingly, researchers are revealing how drivers utilise their spatial knowledge to respond route guidance information (Abel-Aty 1993, Yang *et al* 1998, Khattak and Khattak 1998, Schofer *et al* 1999, Mehndiratta *et al* 1999, Adler 2001). How drivers learn to utilise this increasingly accessible traveller information represents a strong focus for this paper.

Lessons from Adult Learning

While schooling is usually considered as a structured experience for children, adult learning is generally defined in a broader social setting where the developmental readiness and intellectual capacity of the adult may be less important than motivation or social necessity. As life long learning and continuing education have become recognised in a contracting employment market, the relatively new field of adult learning has become an increasing research interest (Jarvis 1987, 2001).

Knowles (1980) further submits that adult learning has a time based perspective. Adults learn something in order that they can use it immediately, rather than learning for learning's sake. Thus, after having identified a need to learn something within a certain time frame, adults fulfil their needs through active participation in the learning process to close the gaps they have discovered.

Dewey (1933), Lewin (1948), Kolb (1984) and others have described this particularly adult response to perceived need as 'experiential learning'. Knowledge, they argue, is created through the transformation of personal experiences. Kolb and Fry (1975) identified a four step experiential learning process beginning with concrete experiences and reflective observation that may lead to subsequent active experimentation and abstract conceptualisation. This learning cycle, they argued, repeats itself continuously as experiences accumulate in the course of daily living and travelling.

The importance of experience as a source of learning and development has been well articulated by Ausubel (1968), who said:

> *"If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly."*
>
> *(Ausubel, 1968 pvi)*

and supported more recently, with a suggested teaching approach by Burns (2002):

> *"the most important contribution a teacher can make to the adult's learning of cognitive information is to select, organise, translate and present the new material in such a way as to enable the learner to appreciate its relationship with ideas, concepts and principles which they already have in their memory."*
>
> *(Burns, 2002, p128)*

In this context, drivers' learning of traffic may be recognised as a special case of adult learning. Until now, little has been written about it. But it is fair to say that most drivers, especially commuter drivers, have broad traffic experience and knowledge. If he had been speaking of driver learning, Ausubel might well have said, *"Find out what drivers know, and then teach them accordingly."* We argue that the answer to the question, "What traveller information do drivers want?" lies, necessarily, in finding out what drivers already know.

3. Methodology

The preliminary findings presented in this paper arise from a qualitative case study based on semi structured interview data designed to examine and understand the information needs of drivers. The findings derive from a modified content analysis of in-depth interviews (after de

Araugo 2000) with a sample of drivers who had recently completed a traveller information trial in Melbourne (population 2.5 million), Australia.

The research design for this study was developed to:

1. explain how drivers learn about traffic
2. understand how additional information is used by drivers; and
3. generate a model of the evolution of drivers' learning in response to pre trip and en-route traveller information.

The research design was predicated in at least three strongly held views and assumptions of the authors:

1. that most drivers have yet to experience dynamic, real time traveller information customised to their individual needs. As a consequence, results from market surveys are inconclusive as drivers are unfamiliar with the potential of such information.

2. that drivers are, at the same time, both experts and novices. Drivers who may be considered 'experts' on their regular commutes become essentially novices in unfamiliar territory or at unfamiliar times on regular routes. Furthermore,

3. that drivers learn. When new traveller information becomes available, drivers rapidly learn how to apply it to their immediate needs and then to incorporate it with their existing knowledge.

Content analysis of the tape-recorded interviews involved creating categories which classify the meanings expressed in the data, and then coding, tabulating and illustrating the data to establish both its qualitative construct validity and its reliability (Burns 1998).

The respondent drivers were volunteers drawn from a larger study of drivers who had recently participated in a traveller information trial which lasted over a six week period during winter 2001. Thirty employees of a single Melbourne company received traveller information comprising estimated journey time from home to work and work to home, incidents and weather via SMS. Participants compared the information they received with the actual journey times they experienced over a six week trial period. The objective of the trial was to test the accuracy of the traveller information service in providing customised information to subscribers (Trayford and van Leersum 2002).

The trial population thus afforded the authors a unique group of drivers who had, as a result of the trial, shared a common exposure to the traveller information described. The study respondents comprised 5 males and 5 females, all of whom drive to and from work daily and who were identified by the company management as broadly representative of the 180 employees within the company.

The respondents included married, divorced and single men and women ranging in age from mid 20s to mid 50s. Households involved a range from singles and as-yet childless married couples to single parents bringing up young children and couples with grown children. In keeping with their age, gender and household differences, respondents ranged in seniority and training from junior programmers and personal assistants to senior executives.

To meet privacy and confidentiality requirements for the research, no individual or organisation is identified in the paper. Fictional personas have been developed to safeguard the identities of specific respondents.

4. Findings

Drivers want traveller information but each need is different

The responses of the drivers in this study confirmed the findings of earlier researchers that many drivers desire information and gain a certain degree of comfort from knowing that information.

> *"every morning you get in the car and you don't know. You don't know until you hear something or you know something. So I think it gives you a level of comfort and time to travel and incident impact." – Yvonne*

Each driver however wants slightly different traveller information.

> *"I'd like to know if there's anything that's going to cause me problems on the way to work. Be it an accident, or lights not working or boom gates stuck down at railway crossings." - Thomas*

> *"even suggestions of alternative routes. Is there a better way to travel rather than what you know? Maybe somewhere you don't know that could assist you. So rather than taking main roads, is there a back road way, a less busier way even." – Anne*

> *"I would want information about say, the 3 best routes that I could take to get to work, bearing in mind also that I would have to drop my partner off in the city." – Richard*

> *"First of all I would make a decision about where I would want to know the information and I would call up and say, this is where I am, what does Punt Road look*

like at this point in time? Is traffic already banked back? Is it unusually busy? Is there anything I should be aware of this morning with Punt Road?"– Madeline

"Before I left home, I want to know how long it's going to take me, but I actually want the information to say that if I want to get there at 9, I want it to message me 5 minutes beforehand, "you need to leave now". That, I would find a lot more useful than saying it's going to take you 45 mins to get to work, when I have to be there in half an hour. The only other things would be the actual incident." – Andrew

In strong alignment with previous studies, this study confirmed that most drivers want information of a predictive/analytical nature rather than merely an announcement that there has been an accident at a particular location.

"First of all the fact that there is an incident, there's been a massive 20 car pile up on the Monash Freeway, so it's a complete write off this morning. Great, OK, Great to give me that. We suggest the best alternative route given current traffic flow is whatever, try Dandenong Road to __ , whatever, and on current travel times we estimate its going to take 50 minutes to go that route this morning. Because I may have already set up a meeting at 8:15 this morning and then I can ring through and tell someone that I am going to be 10 minutes late for that meeting. That's what I would need." - Richard

Less experienced drivers wanted more descriptive situational information (eg "accident at A and B street") while more experienced drivers, although also wanting situational information, required less detail, because they asserted, they already had a clear idea (a mental map of the situation) in their minds.

Motivated drivers (regardless of experience), however, identify different information needs from drivers with no urgent trip purpose:

"The other thing that would be useful is if you knew where I was going, which you would, could you also give me up to the minute advice on how my other alternative routes were looking. Is it a good move to go this way or isn't it. I mean that would be really nice. If you make your move now and you branch off at the next exit, then you are going to beat the congestion there and it's not a bad idea to do so." - Nigel

As suggested by Keever and Pol (2002), the information that drivers claim to need and value can be categorised as:

- simple data about incidents and events,
- situational analysis of the incidents and events; and
- prediction of the impact of the reported situations.

Describing his 'simple need' for data, Andrew expressed a need for information that would integrate with his spatial knowledge: "*Given all the data you want, you still have to make decisions as to where to go, so you want to know exactly where it is*."

Other drivers described their need for situational and predictive information in the following manner:

> *"You don't just want to know the accident, you want to know the accident and the potential impact. You need to understand, if it's an accident that's happened on the other side of the road, then it's a clear run basically, if it's an accident that's happened in the middle of the road, then the impact is going to be completely different. So it's not just the accident, it's the potential impact of that accident as well. If it's a fatality, well you can guarantee that the road will get closed. So there's an impact straight away. So you know you can't travel that route any more." – Anne*

At a different level of route experience, however, drivers express different needs:

> *"There are some key things I like to hear. Like traffic banked back to here, I'd be like great, I can make a decision on that. I don't need to ask anything further. Accident here, I want to know something else. How long will it take to clear up, what does traffic look like now. These logical questions." – Madeline*

In the absence of traveller information services providing much more than incident and event data, most drivers internalise their data fusion processes individually. As Anne remarks,

> *"Because I travel the same route each day, I can certainly analyse and work out what the impact is going to be." – Anne*

At this point, it seems that the extent to which drivers are capable of fusing data is closely related to their knowledge of spatial and traffic conditions. Clearly, then, traveller information services do have the potential to assist drivers by providing them with *relevant* information. However, even in its apparently simplest forms, traveller information content may be simple data or situational and predictive information. Driver demand for, and hence valuing of, information appears to depend on the trip intention of the driver, their level of experience with processing information and with driving a given route, and the driver's purpose for undertaking the trip.

Drivers are experts on their commutes, but less experienced elsewhere

Further examination of the interview data suggests that drivers are experts on their commute trips but, as would be expected, less experienced on other journeys. Drivers usually know their commute route very well and can describe it in great detail.

> *"I live in Blackburn. I left at approximately 7:35am this morning, which is later than normal. I take Blackburn - Canterbury, Canterbury – Middleborough to the*

> *Eastern Freeway. I go down Blackburn to Canterbury because Blackburn has the dog leg to the Eastern Freeway that gets messy by the station. So then I turn left onto Canterbury Road, go down to Middleborough Road and then right to Middleborough and take that to the Freeway and then cross over and hit the Freeway down there. Eastern Freeway and then Eastern to Hoddle and then straight here. I get to work at 8:05." - Sarah*

Expert commuter drivers have a good understanding of factors impacting journey times during their commutes as Madeline observes when she unconsciously describes the shape of the morning peak.

> *"I either decide whether I am going to come in early, so I can have an early day, and I'll leave between 7 and 7:30am, so it's not a very stressful drive. The traffic is just starting to build. If I haven't got up early enough, I will consciously go even later. So I will leave at 8:30 or 8:40. It will still take me 30 minutes" – Madeline*

Madeline knows that traffic is heaviest between 7:30 and 8:30am on her route and has identified a "shoulder" period on either side of the peaks, which will enable her to make the journey within 30 minutes. Experienced commuter drivers also tend to know alternative routes:

> *"I possibly have two or three options just to travel to work. And the options are to generally to go on the Eastern Freeway, the South Eastern Freeway or to take the residential roads and come down Canterbury Road and Burwood Highway and wind my way through the traffic" - Mary*

Experienced commuter drivers have lived in their area for some time and have accumulated a sound degree of spatial knowledge of their area. However as Yvonne admits, she is less familiar on other routes.

> *I know every street, every way, every thing. It's not a problem. You know what I mean. I can get anywhere in Caulfield, Malvern, Elsternwick, Armadale. I've grown up there my whole life. <u>But I haven't, never in my life been to the Eastern suburbs. I've never even been there. So I have no familiarity whatsoever.</u>" – Yvonne (underline is authors' emphasis)*

Yvonne's observation raises important implications for the ongoing provision of effective traveller information. The knowledge and expertise of an individual driver is not uniform across all journeys undertaken and therefore the driver's requirements of traveller information also vary.

Driver Learning is a special case of Adult Learning

Drivers are motivated to learn. They learn through trial and error and they learn in social settings from other people including other drivers. Respondents to this study identified no for-

mal means of learning. The traffic knowledge that drivers had built on the basis of their accumulated experiences remained tacit (Polyani 1958) as opposed to explicit knowledge.

> *"I've got sense of what's likely to be the best route. Not necessarily in terms of just length, but more importantly in terms of time factor. (It is based on) a combination of factors, I think. One is that it's a route that you are aware of, so you know the roads you're going to be using, you've got a general sense of direction. But more importantly, in terms of preconceived ideas of…. you know what the likely traffic flows are going to be on that particular route." - David*

At a basic level, it seems, drivers believe that they learn through trial and error. Across the period of this study, respondents had been located at their new office for only twelve months. As a consequence, questions about choice of a best route to work were all being answered from a common experience of trialing ways to get to their new office. One respondent described the learning process she went through as follows:

> *"It probably took about one and a half months because first you have to experiment going in and there's lots of different things that influence the traffic as far as I am concerned. We moved in around October, so I got used to normal traffic. When school is out, that makes a difference and holiday periods makes a huge difference to the traffic, not on the Freeway but the traffic around accessing the Freeway. Because we are close to the Freeway and there are no schools during the holiday period, it takes me far less time to get onto the Freeway, if I want to use it. My alternate routes include Malvern Road, I tried Glen Iris Road. Instead of going forward and around the Freeway, I've gone in behind. Coming home is not too bad. See, I experimented both ways. Initially I talked to people who travel a similar route in, so live in a similar area to myself. When we were looking at buying the property, I actually got the Melway out (the Melbourne street directory) and had a look through, and went OK, what are some of my alternatives. Because at the time, I was working in Hawthorn and then moving to Collingwood actually was going to make a big difference. I was just looking at different alternative routes. The other thing is previous knowledge I have of the area. Like I used to live in Richmond, so I knew back streets in Richmond. I knew quiet ones there and colleagues who travel in different ways give you some ideas. A bit of trial and error." - Madeline*

Madeline's approach is more conscious, however, than some other respondents and since there appears to be little difference in driver experience, it is tempting, even on a small sample, to suggest that strategies may be gender differentiated:

> *"Usually just follow my nose pretty much. I get to know where things are pretty quickly. The major roads, I have pretty much set on now. I have sort of worked out a few different ways and the majors roads, after about 3 months of living there." – Andrew*

and

> *"..when you're driving, you're always wondering why people are doing that . You sort of think, he's going right, what's he doing and you get to the next set of lights*

> *and you see him coming the other way and he's gone. So ah, that's the way for me, I'm going that way." - Thomas*

Like Madeline, a number of drivers learnt about route alternatives by asking friends, relatives or workplace colleagues. Thomas, Andrew and Madeline report talking to friends in the area while Yvonne observes, *"My husband's from the area and that's the way he goes, so that's the way I go*". Similarly, Sarah reports, *"I know people who live in my very same block, that will go down the South Eastern Freeway."*

The findings reported in this study support the view that drivers learn according to well established principles of adult learning. As active participants in the learning process, their traffic knowledge is not gleaned from a textbook. The findings show drivers involved in an experiential learning process motivated by the desire to arrive at work punctually using their preferred transport mode.

Drivers start on a learning curve with new traveller information

Preliminary findings from this study suggest that drivers quickly begin to integrate information into their existing knowledge base to generate new learning that leads towards more informed decision making. Within a week of entering a new traveller information access trial, individual drivers related immediate travel time they received to previous experience to reach an increasingly accurate conclusion about the degree of congestion they would face for the current trip. When alternative routes were suggested, drivers began to time their trips to compare, experiment and generally became more sensitive to their new learning.

With access to appropriate information, drivers actively engage in trial and experimentation:

> *"I would have my computer always on. I would say give me the traffic along this route. I could almost map out the route I want. And that could come on the phone. Approximate time, approximate conditions. And then I would say, give me this route, choose the route, give me the next route and up would come another one." - Mary*

However, as new traveller information is rapidly integrated into existing expertise, - even for a new route - and a new learning curve is rapidly traversed, drivers want more.

> *"Ironically, I got less value because it was important early on to know that it was 33 mins or whatever, but like after 6-8 weeks, towards the end it was just telling you the same information you already had, for 6 weeks straight. Unless there was a change in conditions, the value of the information diminished. So then it becomes the case, you need to add some additional content to make it of value to me. Cause you already told me 6 weeks ago its 33 minutes, and if there's no change, it's pretty much a normal morning. And then I am just getting a normal message, and I am*

> *saying yeah, so, I know that. You're not giving me any additional information." - Richard*

Instead, perhaps, drivers begin to generate the level of complexity they require from the traveller information system by integrating their own information:

> *"You got a sense of like now when I see those Freeway signs where you actually got time frames on them, that's makes a big difference. Cause if it's light and it's a 4 minute drive, or if it's light and a 7 minute drive. It does take time to work out what is light. The indicator that I have on High Street Road, you have got to gauge, is it a medium light or is it a light light. I generally do that by the time of the day. When it says it's light between 7:00 and 7:40, it's a genuine light, anytime after 7:40 to 8:00, it's bordering. After 8:00, it's usually medium to heavy." - Madeline*

The study strongly suggests that experienced drivers, at least, utilise traveller information, quite critically. They reflect on the new information and integrate it into their existing framework with a personalised meaning attached ('*light-light'* in Madeline's case), before quickly demanding more complex, interpretive information, possibly in a different format. Richard might be satisfied with a 'threshold' alert, eg, only inform him if his predicted commute time increases by more than 15 minutes or 20% above normal. Madeline observes that the metric on the indicator board - light, medium or heavy traffic - is too coarse for her requirements. Increasingly fine metrics, however, may confuse less experienced travellers.

Implicit in the notion of a learning process, as it is observed in this study, is that drivers' information requirements change as they progress along the learning curve. Richard anticipates his own needs as a learning consumer of traveller information when he suggests that:

> *"The way you could structure it, based on my experience is you have a service for 3 months, where you are provided information on a daily basis, until after three months you work out that it has a diminishing return. And if the service is an annual subscription, for the remaining 9 months of that service, you're only sent a message when its required, when there is a delay or change in traffic circumstances. But you need a 3 month period, a quasi trial period for you to ascertain that's really all you need. But you could sell an annual subscription package which would have that components." – Richard*

Richard suggests that he might be willing to pay for a 'diminishing' service. He proposes that a feedback loop supporting continuous learning yet capable of changing level depending on driver familiarity with their route might be more appropriate. As drivers learnt, their ability to analyse and synthesise information progressed to a point described by Keever and Pol (2002) as Level 4 in data fusion; where a meta process was applied to refine information provision.

> *"(If I received) a message today saying 45 minutes and tomorrow saying 60 minutes, I would immediately see that either there was a simple factor increasing times, and that could be simply be that there's more people travelling down the Freeway.*

> *Or the other factor could be accidents. Any of those sorts of things. You would think if there was a time impact, there was a factor impact. Something caused that time increase. It could be the weather, the amount of people, etc, etc, it wouldn't just be one day its 45 minutes and another day its 60 minutes for no reason. There has to be a factor impact." - Anne*

The progression of drivers along a new learning curve in response to the provision of traveller information results in their subsequently wanting slightly different information. Their new found knowledge does not apply equally across all journeys undertaken. The same driver will continue to need basic (Level 1) information on infrequently made journeys because the knowledge base for this trip is not as extensive as on the commute trips. The need for the traveller information service to support knowledge integration or 'fusion' from all levels, remains unchanged. It is the information needs of the drivers that vary.

5. Conclusion

Drivers principally learn from their experiences. By the time they begin to learn to drive, they already have experiences that have accumulated since their early childhood. As pedestrians and cyclists, as public transport commuters, and travelling in the back seat of their parents' cars, learner drivers accumulate the skills of driving. Passing their basic driving test, they graduate into that community of drivers travelling the road networks of our cities. Continuously gaining experience, some meaningful, some apparently meaningless, drivers accumulate traveller knowledge throughout their driving lives. What they do with their experience, this paper argues, is relatively poorly understood. It is also poorly considered in the development of many traveller information systems.

After learning to drive, it is generally assumed that drivers have no further need for learning. Most obviously, this assumption is displayed in the absence of any further formal learning, apart from uncoordinated and occasional advanced driver training and 4 wheel drive courses in some countries. Integration of research findings from the fields of adult education and traveller information provision suggest that experienced drivers confront traveller information system designers with the special case of learning reported in this paper.

In particular, the varying skill levels and needs of the driver have been identified as discrete intervening variables in initial information uptake and subsequent integration. As a commuter, the driver goes through a period of experimentation on routes to and from work, using past experience and knowledge and advice from friends and colleagues. Experimentation levels decrease quite rapidly, a regular 'favoured' route is chosen and the commuter driver becomes relatively expert on that route. Faced with variation, such as travel to a business meet-

ing or a personal appointment, the same driver may be substantially less expert than on the commute trip. The data suggests that a commuter driver travelling a route for the first time displays little more expertise than an inexperienced driver.

Compared with generalised information such as weather reports, the provision of customised traffic information for drivers remains in its infancy. The findings reported in this paper suggest that commuter drivers presented with dynamic, customised traveller information enter a learning curve affected by previous experience and immediate need where learning to access and utilise appropriate travel data is a dynamic process. More importantly for systems developers, however, the time required for experienced drivers to integrate information is relatively short. Additionally, experienced commuter drivers rapidly become conscious of the shortcomings of a novel traveller information package. While there is little evidence provided by this study to suggest that the speed with which expert commuter drivers learn impacts their continued attention to the novel system, it seems likely that the increasing lack of relevance of the system leads to the levels of exhaustion with and eventual disuse (even abuse) of existing systems – our own included.

Design of an effective traveller information system necessitates the targeted provision of information, sensitive to evolving driver capacity. This paper proposes that future work must proceed on twin fronts:

- developing effective techniques for categorising and profiling driver experience, preferred learning style; and cultural personality type at entry and in evolution; and,
- developing procedures for matching content to the driver's processing capacity.

Customised traveller information will become effective when it meets the current understanding and needs of the driver as an active learner whose information requirements change over time and from time to time. Further work in these areas will lead to better customisation of information for the driver and reduce the rapid rate at which proposed systems fall from grace.

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