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Modelling Drivers' Car Parking Behaviour using Data from a Travel Choice Simulator

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ABSTRACT

This paper reports on models developed from data collected using the PARKIT parking choice simulator. PARKIT provided an experimental environment in which drivers' choice of car parks, and of the routes chosen to reach them, could be observed and the influence of different levels of parking-stock knowledge (derived from experience or from information provided via roadside message signs) monitored. Separate models were estimated for the drivers' initial choice of car park and for their revision of that choice as their journey progresses and they learn about actual conditions. The importance of price, walking time and driving distance is confirmed but the addition of variables describing the drivers' choices on previous days, their expectations and their immediately preceding route-choice, greatly improved the models' explanatory power. It is noted that variables such as these are not generally considered because they are rarely available to the modeller. Different discrete choice model structures were found to be appropriate for different decisions. Route choice was represented as an exit-choice model (whereby each journey is treated as a sequence of decisions – one at each intersection encountered). The paper discusses the incorporation of these choice models into a network assignment model and concludes that much of the power of the choice models is lost if the network model is not able to support use of information about travellers' socio-economic characteristics and knowledge of the network and about the detailed network topology.

Keywords:

Modelling, Behaviour, Data, Simulator, Parking, Choice, Disaggregate, Experiment, Habit, Learning

1 INTRODUCTION

1.1 Background

As congestion in urban areas continues to rise it becomes increasingly difficult for drivers to find conveniently located parking spaces. This in turn brings problems for the urban economy and the environment; perceived shortages in parking can dissuade people from travelling to the city centre for work and leisure, while those that do drive in the centre spend unproductive time searching for spaces or waiting in queues, thus further exacerbating congestion. Surveys of drivers undertaken in British cities over the past ten years or so have indicated that up to 25% of the average total travel time of journeys to central urban areas is taken up in searching for a parking space (Polak & Vythoulkas, 1993) while a study in Frankfurt (Axhausen *et al*, 1994) put the proportion during peak congestion at 40%. Research in London (May & Turvey, 1984) calculated that between 30% and 40% of the travel distance for journeys terminating in the central area was attributable to parking search.

In an effort to reduce these problems, an increasing number of city authorities are introducing dynamic Parking Guidance and Information (PGI) systems which, via roadside variable message signs at some distance from the parking facilities, offer drivers real-time information on parking space availability and help them to make more informed choices. Such systems, first introduced in Aachen during the early 1970’s, should also lead to a more efficient utilisation of the parking stock by directing drivers away from congested sites and towards relatively under-utilised ones.

According to research by Leichter and Schober (1985), full compliance with a system of *static* parking direction signing could lead to a reduction in average journey time of up to 25%. The potential benefits of a *dynamic* PGI system should be even greater but will crucially depend on the level of compliance achieved. Factors affecting compliance have been found to include: how information is disseminated; journey characteristics; parking preferences; and the level of familiarity and local knowledge of the driver population (Axhausen *et al*, 1994). The drivers who find PGI systems most effective tend to be visitors who are unfamiliar with the local parking sites and so have no strong parking preferences. More frequent drivers, with local knowledge of parking opportunities, are faced with trade-offs between search time, price and location (with consequences for driving time and walk time).

The information that PGI systems offer has to be incorporated into an already complex parking choice and search process. A number of researchers have sought to understand these trade-offs and to model this decision process - see for example reviews by Young and Taylor (1991), Young *et al* (1991), Muromachi *et al* (1992), Polak and Vythoulkas (1993), Polak *et al* (1993), and Thompson and Bonsall (1997). It is generally agreed that the existing models have suffered from a shortage of good data on search and choice processes; hence our interest in new sources of such data.

1.2 The Role of Simulators

Substantial use is now being made by behavioural researchers of simulators which allow close observation of subjects acting in an experimentally controlled world. The ‘travellers’ are asked to undertake journeys which involve making choices in response to stimuli provided at various points in the trip. The representation of the travelling process differs between simulators depending on the level of computing technology available and the precise nature of the experiment. However, all simulators share the common feature of placing subjects in semi-realistic travel environments which allow for efficient collection of data on aspects of their behaviour. Simulators provide the opportunity to collect data on behaviours and situations which would be difficult to study in real life and which might not be so reliably collected with standard questionnaires. It is argued (e.g. by Bonsall, 1993, and by Koutsopuolos *et al*, 1995) that they have a particular role in the exploration of responses to as-yet-unimplemented components of the transport system such as the various forms of information and driver assistance currently under development.

Simulators have been developed for a wide range of purposes within the field of traveller behaviour research. They range in complexity and expense from full scale driving simulators such as those owned by major car manufacturers to PC-based devices which are, in effect, animated or illustrated questionnaires (e.g. Swanson *et al*, 1997). The most complex/expensive simulators have a manifestly high degree of ecological validity and their use is appropriate when considering man-machine interface (MMI) issues, particularly those related to safety. A particular growth area, however, has been in the use of much cheaper, PC-based, devices designed to provide a more or less realistic environment in which to study subjects' route choice behaviour in a range of circumstances. Several examples of such devices, usually known as 'travel simulators' or 'route choice simulators', are conveniently reviewed by Koutsopoulos *et al* (1995) or more recently by Bonsall (2003). The validation work undertaken at Leeds with the IGOR and VLADIMIR simulators (Bonsall *et al*, 1995, 1997) lead to the conclusion that such simulators provide a very useful method for collection of data and that, if carefully designed, they can engender route-choice behaviour which is almost indistinguishable from that observed in real life. A particular feature of these simulators is that the experimental subjects can experience a wide range of option attributes in the context of the simulated journey rather than, as is the case with more conventional stated preference methods, having a subset brought to their attention via an abstract list of attributes. This more naturalistic approach should give the analyst more confidence that, if an option attribute appears to be influencing behaviour, this is not simply because it was brought to the subject's attention in the option descriptions.

This paper describes models built on data from a simulator developed at the University of Leeds within a joint research project with Imperial College and the University of Southampton. The project was funded by the UK Engineering and Physical Sciences Research Council and aimed to explore the effectiveness of PGI systems. The simulator ('PARKIT') was specifically designed to explore the influence of PGI on parking choice and search behaviour. PARKIT is similar to VLADIMIR in that it includes a fairly faithful representation of the range and relative duration of the various stimuli involved when making a journey, and thus differs from other 'parking choice simulators' (see Jones *et al*, 1994, and Kurauchi *et al*, 1997) which do not seek to do this.

2 DESCRIPTION OF THE TRAVEL SIMULATOR USED IN THE STUDY

2.1 Introduction

A PARKIT session lasts approximately 45 minutes and comprises:

- an introduction to familiarise the subject with what is required of them and to allow them a 'test-drive' in a simple network;
- a series of five journeys made by the subject in the simulated world;
- questions asked of the subject before and after each journey, and at the end of the session;
- a series of more detailed dialogues with the subject after completion of their final journey.

PARKIT runs on a portable PC. Its software maintains a log of all decisions made, and of all answers provided by the subject. This facilitates subsequent analysis and allows for very detailed investigation of the decision process.

2.2 PARKIT's Representation of the Travel Experience

PARKIT provides a fairly detailed representation of the travel experience including driving, searching for a parking space, queuing (if necessary) and walking to the final destination. Key aspects of this experience are the context, audio-visual stimuli, the representation of the passage of time, and driver control.

The context

Prior to each journey, the 'driver' is supplied with text describing the context of the journey he/she is about to make. This includes the journey purpose and other relevant information such as any required time of arrival at the specified destination.

Audio-visual stimuli

These include:

- a driver's-eye view of a car dashboard including an animated clock, odometer, speedometer and view through the windscreen (see Figure 1a);
- a sequence of computer-generated through-the-windscreen views of the urban streetscape along the route 'driven' by the subject. New views replace earlier ones at a rate which reflects the speed and a turn to the left or right causes the view to slide sideways in the appropriate direction. The use of digitised photographs of real street scenes (as is done in VLADIMIR) was considered but, rejected because it would have constrained the experimental design and risked giving the subjects unwanted cues from the photographs (see Swanson *et al*, 1997);
- roadside signs and parking information as seen through the windscreen (see Figure 1b);
- through-the-windscreen views of conditions while queuing to park (see Figure 1c) and while driving within an off-street car park (see Figure 1d);
- an engine sound which is emitted while the subject is 'driving' and whose note is proportional to speed;
- a pedestrian's view of the walk from the car park to the final destination.

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Representation of the passage of time

Previous work with VLADIMIR suggested that time spent on different elements of the simulated journey is an important determinant of the subject's perception of the journey and hence of their behaviour. PARKIT seeks to ensure that the subject experiences the consequences of his/her decisions in a very direct way. For example, completion of an off-side turn (crossing a stream of traffic) takes longer than that of a near-side turn, a decision to enter a queue is followed by an enforced wait, choice of a car park at some distance from the final destination results in a time consuming walk.

Perception of the passage of time is dependent on the nature of the activity being undertaken - particularly how stimulating it is. Thus there is a case for differential factoring of the time spent driving, queuing, searching for a space within a car park, and walking to the destination. In the interests of efficiency of data collection, PARKIT journeys have to be represented in less than real time. In order to complete four or five journeys within a 45 minute session, the overall journey time needs to be reduced to roughly a tenth of real-time. This constraint, together with the conventional wisdom that excess time is perceived to be twice as irksome as in-vehicle time, led to the adoption of a 1/12 factor for drive time and a 1/6 factor for queuing, parking and walking time.

The subject's perception of the passage of time is reinforced by the dashboard clock (running at an appropriately accelerated rate) while he is in the car. During the walk to the final destination this function is performed by an animated wristwatch and an empty rectangle whose initial length is proportional to the distance to be walked and which is progressively filled from the left as the subject 'walks' this final stage of the journey.

Driver control

The subject controls the ‘car’ by pressing appropriate keys on the keyboard. The options available to the driver at any point in the exercise are highlighted in red in the centre of the dashboard. While driving, the options at each intersection are to continue forward, turn left or turn right; when a car park is reached the options are to drive on or enter the car park (joining the queue if there is one); and after joining a queue the driver has the option of leaving it to rejoin the road. Choice of an option is confirmed by the highlight turning yellow. A decision to turn left or right is confirmed by a light on the dashboard flashing yellow while a ticking (‘indicator’) sound is heard.

On-line help, for example to remind the subject of the options currently available or of the journey purpose and expected arrival time, is accessed at any stage via a special key. Use of the help facility is logged for potential analysis along with other items such as the amount of time taken by the subject to make each decision. Other features of the interface include display of a compass among the equipment on the dashboard and provision of text at the bottom of the screen to inform the ‘driver’ of his/her current location. These features can assist drivers in navigating in the simulated city.

2.3 Representation of knowledge

Before each journey the subject is given a hardcopy briefing sheet which represents the prior knowledge he is assumed to possess. By varying the amount of information shown on the sheet, different levels of prior knowledge can be simulated. Figure 2 shows examples of sheets appropriate to different levels of prior knowledge. Figure 2a is quite schematic and might represent the sketchy knowledge possessed by a first-time visitor to a typical Europeanstyle city. Figure 2b contains much more detail including the price and expected fullness of each car park – a level of detail which implies considerable familiarity with the city and its parking stock. Note that expected fullnesses are presented in terms of probabilities of having to wait more than five minutes to get into a particular car park and that they are expressed both as 'percentage chances' and as 'x times out of y'. This mode of presentation was chosen after some experimentation with alternatives and allows for differences in the way people perceive probabilities. Although use of the hardcopy sheets necessitates the presence of survey staff to administer them, this arrangement proved better than providing the prior 'knowledge' via the screen. (Subjects often wish to consult their 'knowledge' while making the journey and toggling back and forth between the journey screens and 'knowledge' screens could be quite confusing for them.)

The second important source of 'knowledge' is, of course, the experience which the subject accumulates on each journey. If a subject makes a series of journeys in the same network they may be build up their own picture of the network structure, the traffic conditions, the location of car parks, their prices, typical delays encountered when entering them and the walking distance required to reach the final destination.

The third source of knowledge, and the original motivation for our research, is information displayed on roadside signposts or via PGI displays. PARKIT subjects are provided with this information via their windscreen views (as in Figure 1b).

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2.4 Questions and Dialogues

Although the simulated journeys are the main feature of PARKIT, the questions and dialogues fulfil an important function in the experiment. The questions are designed to elicit information about the subjects' perceptions, expectations and intentions before setting out on the journey and about their impressions immediately afterwards. Questions asked before starting the journey focussed on the drivers' intentions and expectations (see, for example, Figure 3a) while questions asked after the journey were concerned to discover whether the driver was satisfied with the route and car park they had just used and whether, on a subsequent occasion, they might set off at a different time or choose a different route or car park. Note that questions are not asked *during* a journey because, even though it would be useful to get data on how perceptions and intentions alter during a journey, en-route questions would detract from the primary goal of making the journeys as realistic as possible.

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Once sufficient journeys have been completed, PARKIT enters 'dialogue' mode which enables subjects' responses to a range of specific stimuli to be assessed more quickly than during the main journeys. Each dialogue comprises a series of 'what if?' questions which can, for example, explore the effect of different PGI information on expected wait times at car parks. Thus a dialogue might involve displaying a given sign and then asking a series of questions - as in Figure 3b. It may be supposed that, because the subject will by this stage have just completed several PARKIT journeys and have experienced the consequences of their decisions, the answers to these questions will be more reliable than would otherwise be the case.

Once all journeys and dialogues have been completed, or if an interview duration limit has been passed, a series of debriefing questions are asked. These collect socio-economic characteristics and attitudinal data as well as asking the subject's opinion of the realism of their behaviour in PARKIT. This question enables data to be flagged for exclusion from subsequent analysis if, for example, the subject does not maintain that their behaviour in PARKIT was the same as it would be in real life.

2.5 Experimental Design

The experimental design was intended to produce data to support investigation of the factors affecting drivers' choice of car parks and the influence of PGI information on that choice. It was further intended to reveal whether behaviour was dependent on the characteristics (age, sex and income) of the subjects, the extent of their prior knowledge of the network and parking stock, and the nature of the journey being undertaken. These issues were catered for via an experimental design which allocated subjects to a configuration of five journeys and two sets of dialogue questions.

The map in Figure 2b shows the network and car park stock used throughout the study. The layout includes interesting route and car park choices such as those between the route to the town centre (with its range of car parks) and the route to the station (with its single, less centrally located, car park) or between Church Street (with its single car park with 200 spaces) and High Street (with its two car parks with 100 spaces each). Although we were interested in subjects' behaviour in networks with which they were not very familiar, we did not, in these experiments, wish to study the problems which occur when drivers get lost. We therefore took steps to make navigation easy; for example, the network was a simple grid, all streets and car parks were descriptively named, the pre-trip briefing sheets included an annotated map, a compass was included on the dashboard to complement the north-arrow on the map, and text was provided at the bottom of the screen to indicate what street the driver was currently on and which way he was heading.

The drivers' level of prior knowledge was controlled via the pre-trip briefing sheets. Each subject made one trip with minimal information on the sheet (as in Figure 2a which only indicates the basic structure of the city and that there is parking at the rail station) and then four more trips with much more information (as in Figure 2b which provides full details of the network and parking stock including prices and typical risks of having to queue). The drivers' experience of the network was allowed to build up through each journey made.

Two journey purposes were employed in the experiments; one was a journey to "an important business meeting" which was due to start at 0830 (the current time being 0800), the other was an off-peak shopping trip. Each purpose had an associated destination within the city centre. Half of the subjects were allocated to each journey purpose and retained that purpose for all five journeys.

Three different regimes of parking charges were devised, each giving rise to a different expected pattern of queuing at car parks. (The table under the map in Figure 2b is an example of one such regime together with the resulting expected queuing pattern). Each subject completed two journeys under one regime and then three more under another regime. They were informed of the current regime of prices and expected queuing pattern via the pre-trip briefing sheet. There was, however some daily variation in the queuing pattern and drivers would not be aware of the precise conditions on any given day until they saw a PGI or reached a car park. All three patterns were primed to include particularly severe congestion in the city centre car parks on the fifth journey.

Two types of PGI sign were employed in the experiments; ones displaying simply either "FULL" or "SPACES", and ones displaying the actual number of spaces available. An experimental design was devised to allow us to explore whether the different types of sign had different impacts on behaviour, whether PGI had a different impact on drivers who were unfamiliar with the city and whether the presence of PGI changed the unfamiliar drivers' perception of the stock. This involved exposing half our subjects to each type of PGI and, across this, having half our sample receive PGI while they were still unfamiliar with the city while the other half did not receive it until they had become familiar. In each case, the subject was provided with an example and text description of the relevant type of PGI system just before the first journey on which they were to experience it.

The content of the PGI signs varied from one journey to the next but was always consistent with the actual fullness of the car parks as it would be when the drivers got to them. For the SPACES/FULL signs, "FULL" was displayed if there would be more than a two minute wait at the car park. A separate study (Lai, 1997) used PARKIT to investigate the effect of varying the occupancy threshold used to control the switching of signs from “SPACES” to “FULL” and found that, if the threshold were raised such that the signs sometimes said “SPACES” when the wait time was excessive, drivers began to ignore the signs.

PARKIT’s dialogue facility was used to explore how subjects’ intended choice of car park and their perception of likely waiting times was influenced by information they saw on the PGI signs. As in the previous 5 journeys, subjects were presented with pre-trip information and a journey scenario and then asked which car park they intend to try first and what maximum, minimum and probable wait times they expected at that car park. At which point, instead of continuing their journey, they were presented with a set of PGI information and asked to review their choice of car park and their expectation of the maximum, minimum and probable wait time at that car park. These questions were repeated for two further sets of PGI information and then the sequence was then repeated with different pre-trip information and three further sets of PGI information.

The overall structure of a PARKIT session is summarised in Table 1.

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2.6 The Surveys

PARKIT surveys were carried out in 1997 and 1998 in London, Southampton and Leeds. The London sample (of 46) were recruited from among regular car drivers recruited at the main shopping centre in Kingston. The PARKIT sessions were conducted at the respondents' own homes. The Southampton sample (of 50) were drawn from an address list collected for the ROMANSE research project; individuals were contacted by telephone and those who were willing to participate in the study were invited in to the university for the PARKIT interview and were offered £10 to cover expenses. The Leeds sample (of 55) were recruited from among employees of companies in Leeds city centre, with the interviews being conducted at the subject's workplace (see Firmin, 1999, for details of the survey procedure).

3. RESULTS

3.1 Preliminary Analysis of the Data

Fifteen out of the 151 subjects thought that their behaviour in real life would be other than what it was in PARKIT and one thought that it would be very different. The data from these subjects was excluded from the subsequent analyses.

A number of interesting tendencies were apparent in the subjects' behaviour and in their answers to questions. Subjects' behaviour during the parking journeys appears to have been intuitively reasonable and there was evidence of some interesting price/wait/walk tradeoffs and of the effect of increased knowledge. Key results, including intentions and eventual choices, are summarised in Table 2.

Row one shows that a majority of drivers on their first (unfamiliar) journey preferred to head for the Station where, from their prior knowledge as summarised in Figure 2a, they knew there would be a car park. However, several of the unfamiliar drivers who had PGI available were persuaded to change their initial intention and to park instead in the City Centre. Comparison of rows one, two and three shows that many of the drivers without access to PGI, although initially wary of heading for the city centre, were prepared to venture there after they became more familiar with the city but, by their third journey, many of them had concluded that the Station was preferable after all. Rows one to three also suggest that PGI was the main reason for drivers changing their mind after their initial statement of intent. Comparison of rows one to four shows that, as drivers became more familiar with the city, they were less influenced by the PGI and more likely to stick to their initially intended car park. On the fifth journey a particularly strong message was displayed on the SPACES/FULL signs (namely that all city centre car parks were full). This message influenced about half those who had been heading for the City Centre to go to the Station instead. Overall it is clear that most PGI messages succeeded in influencing only a minority of drivers **-** most drivers ended up parking in the car park that they had initially intended to head for.

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Analysis of the data from the pre-trip questions revealed a clear link between the expected length of queues at city centre car parks and intentions to use the station car park; the mean expectation of city centre queues was 12 minutes for those intending to head for the city centre but 20 minutes for those intending to head for the station. Preliminary analysis of data from the dialogues (Thompson, 1998) suggested that there were some interesting gender-related differences in the way in which the expected waiting times were influenced by the information provided.

3.2 Approaches to Modelling Behaviour Revealed in the PARKIT Data

The immediate aim of our analysis was to provide colleagues in Southampton with behavioural models which could be used within a network assignment model to predict drivers' response to PGI (see Waterson *et al* 2001). This required us to devise models which would be compatible with the CONTRAM environment in which they were to be applied – a constraint which ruled out many of the more advanced approaches to modelling the impact of information on driver behaviour (see Bonsall, 2000). The CONTRAM model used in the study was able to represent individual travellers with an origin, a destination and an assumed binary level of familiarity with the network and parking stock. The parking stock could be represented in some detail (location, price and, via demand-capacity relationships, degree of congestion and queuing).

The project team took the view that drivers could be assumed to choose a car park before setting off on their trip (with the possibility of revising this choice if they received PGI before commencing the trip – for example via TV, radio or Internet) and that, once they had set off, they could be assumed to drive a path through the network taking account of their intended car park, of their knowledge of other potential car parks, of conditions encountered en route and of any PGI information received. The car park where they eventually parked might or might not be the one they intended to use when they set off. This structure implies at least four decision models: an initial intention, a revised intention (if pre-trip PGI becomes available), some sort of route choice and, possibly, a decision to stop and park. Sections 3.2.1-3.2.4 will discuss the use of PARKIT data to support such models.

Appendix 1 lists and defines the variables used in the models. Numerous alternative specifications were tested prior to selection of those discussed below. In each case the performance of a number of different specifications were compared. Simpler structures and fewer parameters were preferred unless a more complex structure, or longer list of parameters, produced a significant reduction in the final likelihood. In seeking to explain a driver's decisions and behaviour during a given journey we made use of data relating to that journey and to journeys previously made by that driver. This allowed us to pick up any lagged effects or habit effects but, given our decision to use a standard/nested logit structure, ruled out a more formal investigation of serial correlations between different journeys.

Figure 4 indicates the nesting structures referred to in the sections 3.2.1-3.2.4.

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3.2.1 <u>Familiar drivers' initial choice of car park</u>

Prior to each main journey in PARKIT, subjects were asked which car park they intended to head for. The best models of this, based on data from subjects who were deemed to be familiar with the network, are shown in Table 3. Model I1 includes all data, while models I2 and I3 exclude data from subjects who refused to reveal their income. The dominant factor explaining intentions is clearly the tendency of drivers to select the car park they had used in their most recent journey. This suggests that, in PARKIT as in real life, people's behaviour has a strong routine or habit component. The habit component appeared to be particularly strong amongst the lowest income group. The price of the car park and implied walk times influenced the choice; higher income people were less likely to choose car parks which would result in a long walk to the destination. The value of walk time (15.5 p/min) implicit in the ratio of the *price* and *walk* parameters is close to standard values but the absence of a significant income effect on the *price* parameter in Model I3 was surprising (see later discussion). The effect of the prior expectation of queuing delays at car parks was best represent by a simple binary variable and, as might be expected, had more influence on the work journeys (for which there was a tight deadline) than on the shopping trips. Drive time is conspicuously absent from the list of significant explanatory variables, suggesting that, before setting off on their journey, the drivers considered the drive time as being of little consequence in their choice of car park.

Nested models with structures such as that shown in Figure 4a (which reflects the structure of the city network) were estimated but, since the scale parameters were not significantly different from unity, a simple multinomial structure was maintained.

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3.2.2 Familiar drivers' revised choice – after seeing pre-trip PGI

This model seeks to show how pre-trip PGI influences drivers to revise their choice of car park. The data came from the PARKIT dialogues where, having asked drivers which car park they would head for based on the car park attributes and their experience, we introduced pre-trip PGI information and then asked which car park they would now head for. These data were used to calibrate a nested logit model reflecting the network structure: a lower nest for the High St car parks, and a higher nest for the city centre car parks against the station car park (see Figure 4a). The models are shown in Table 4. In Models R1 and R2 the estimated structural parameters are greater than, though not significantly different from, unity and so in Models R3 and R4 the theta coefficients are set to 1. Note that the nested structure was maintained so that PGI information that applied to groups of car parks could be included in the calibration without having to impose an arbitrary process to "split" the information between the constituent car parks.

Model R1 is an attempt to fit a linear parameter to the probability of having to wait (as supplied on the pre-trip briefing sheet) and, unsurprisingly, the fit is poor. R2 indicates that this variable is better represented as a simple binary operator – which suggests that drivers perceive the probabilities in quite simple terms. The relative size of the PGI variables (and their t-statistics) indicates that they are seen as more influential than the information provided on the pre-trip briefing sheets. The *FULL* variable has a strong negative effect in all the models. For the range of spaces for which the models were calibrated, the *#SPACES* and *#SPACES2* variables taken together have a positive effect which is less than proportional to the number of available spaces. The *Intended* variable has a strong positive weight equivalent to the negative weight of a *FULL* PGI – which indicates a reluctance by drivers to abandon their original choice.

Model R3 presents R2 with constrained structural parameters to replicate a multinomial logit model. As expected the change in parameter values, except for *ExpDelLE5*, is negligible. R4 then represents a segmented version of the combined R3 model. This indicates that females are less influenced than males by the PGI information, particularly when the information is presented as the number of spaces still available. Segmentation of *Price* indicates that the under 30s are insensitive to price in the presence of PGI while the over 50s still include it in their decision making.

All three combined models produce values of walk time of round 13p/min **-** which is again fairly close to standard values. The fact that drive time still does not appear in the models reinforces our conclusion that, once other more dominant factors such as price have been considered, drivers are not taking much notice of drive time during their pre-trip consideration of car parks.

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3.2.3 Familiar drivers' exit choices en-route

Our previous work on driver route choice has persuaded us that route choice in the presence of en-route information is conveniently modelled as a series of en-route choices at each intersection reached rather than as a full path or route identified in advance and adhered to whatever conditions are met. We therefore decided to model the route choice within PARKIT as a series of exit choices. The possibility of specifying separate models for route choice on the way to a car park and for the decision to join a queue to enter a car park was investigated but, for familiar drivers, was not found to outperform a single model wherein the decision to enter a car park would be represented simply as an exit choice within the route choice model. The model was formulated such that the utility for an exit was the logsum of the utilities for the car parks that could be reached via that exit. Since at a number of decision points all of the car parks could be reached via any exit, car parks were "assigned" to the exit that led to the minimum distance route to that car park.

Table 5 shows a number of the models calibrated on this basis while Figure 4b shows the nesting structure used. The scale parameter *ThetaE* for logsum of an exit can be interpreted as a spread parameter - the higher the value, the better the model explains the behaviour (i.e. the more deterministic the decision process as implied by the explanatory variables). A single scale has been used for all exits as the model has been conceived as a generic exit choice model – the model does not know whether an exit is, say, an off-side turn.

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A particular feature of these exit-choice models (notably E3, E4, E5 and E6) is the low relative weighting given to the price of parking and the lack of any significant difference in the way that price is viewed by people with different incomes. It appears that, once they set off on their journeys, PARKIT drivers take little further account of the relative costs of parking in the different car parks. This may be because they have already taken this into account in their initial choice of car park - an idea supported by the observation that the *price* coefficient in E2 (which does not include the *Intended* variable) is twice that in E3, E4, E5 or E6 (which do include the *Intended* variable). However, this is not a complete explanation because the *price* coefficient in E2 is still quite low and, as was noted in model I3, there was no significant difference in the way that price was viewed by people with different incomes for the initial choice either. A possible explanation of the relatively low weightings on price is that, while PARKIT provides subjects with a reasonable proxy for the passage of time, it does not ask them to part with money when "paying" the parking charges. The apparent tendency of people to put less emphasis on price when they are on work trips may reflect the fact that the work trip had a time constraint which would cause drivers to prefer an expensive car park with no queue to a cheaper one with a queue.

Females seem to be more off-put than males by a long walk to their final destination but, even for females, the weighting of *Walk* is low relative to that of *Drive.* The low weighting on *walk* is probably due to the fact that walk time, like price but unlike drive time, featured strongly in the initial choice of car park and is thus represented via *Intended.*

The contribution of the PGI variables to overall utility is less than in our I-series or R-series models - which suggests that PGI information may have less impact away from the sign locations. Unlike our previously discussed models of intention, our models of exit choice revealed no obvious gender difference in the response to PGI. Models E4 and E6 suggest a curious income effect in the response to a FULL PGI sign. We have no satisfactory explanation for this.

The net effect of the *Intended* car park dummy which was seen in the R-series models appears to be maintained in the E-series models and we note that older drivers are less likely than younger drivers to change their intentions.

3.2.4 Unfamiliar drivers' behaviour

The models presented in Tables 3, 4 and 5 were calibrated on data from familiar drivers (those whose prior knowledge was obtained from Figure 2b rather than Figure 2a). Attempts were made to calibrate models of unfamiliar drivers' pre-trip choice of car park and of their choice of route but without any success. It appears that, in the absence of prior experience and knowledge, the pre-trip and route choices of unfamiliar drivers were essentially random. In the light of this evidence it was decided that, in CONTRAM, unfamiliar drivers would be represented as randomly selecting a car park near their destination and then following the shortest route to that car park. It was however thought useful to explore the possibility of a model which could represent their decision, having arrived at a car park on their route, whether to stop and park or to drive on.

Table 6 shows models calibrated on the stopping behaviour of unfamiliar drivers in PARKIT (those whose prior knowledge was as per Figure 2a). The models are based only on the length of any queue and the price of the car park (as displayed outside the car park). Their nesting structure is shown in Figure 4c.

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PLACE Table 6 ABOUT HERE

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The models' overall fit is good but this is largely due to the fact that most drivers decided to park at the first car park they came across – a fact reflected in the large value for *Park*. Clearly the drivers were not very particular about the characteristics of the car park and were happy to use the first parking place they found in the unfamiliar network. We recognise that this result reflects the limited nature of the prior knowledge included in Figure 2a - had Figure 2a included details of the car park nearest to the destination then the results might have been quite different.

Contrary to the general stereotype, we note from model S2 that females are more likely than males to be put off by a visible queue. The fact that people were more likely to stop on work trips than on shopping trips may reflect the greater time pressure associated with the work trips.

3.2.5 Expectation of wait time

Although not necessary for the prediction of behaviour in the CONTRAM model, or in general modelling, it was thought it might be interesting to use data from the PARKIT dialogues to investigate the factors influencing subjects' expectations of the wait time at each car park. The analysis was conducted with regression models because they allow a direct interpretation of parameter values and, since the values were found to be approximately normally distributed, a linear regression was deemed appropriate. Two models were developed. The first sought to discover whether the drivers' initial expectation of the most probable waiting time could be explained by the information on likely car park delays provided in the pre-trip briefing sheet (*ExpDel),* the trip purpose (*Shop)* and the driver's gender. The second explores factors influencing the degree to which the driver's initial expectation is modified by seeing PGI information shortly after departure. The results are shown in Table 7.

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PLACE Table 7 ABOUT HERE

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The intercept in model EW1 indicates that, for an office trip, even when the pre-trip briefing sheet suggested a zero probability of having to wait more than 5 minutes, the average expected wait across the initially chosen car parks was more than 5 minutes. This suggests either that our subjects did not understand the information on the pre-trip briefing sheet, or that they were of a pessimistic disposition! *ExpDel* is entered as a linear variable and indicates that an increase of 10% in the pre-trip probability of having to wait at least 5 minutes leads to a 1 minute increase in the estimate of the probable wait at a chosen car park. [Given that the pre-trip briefing sheet presented the probability of a 5 minute wait in percentage terms, other functional forms might be expected to perform better, several were tested but none gave improved model fit.] Although not statistically significant, the *Shop* dummy variable suggests that, other things being equal, longer wait times are expected on shopping trips. Model EW2 splits these parameters by gender and shows that, compared to males, females put much more weight on the information received in the pre-trip briefing sheet and also add more on to their estimates for shopping trips.

Table 7b shows the extent to which the subjects' expected wait times changed after seeing PGI information. Reassuringly, PGI information has a significant influence - if a sign indicates "FULL" the expected wait time rises by an average increase of 3.3 minutes, and the higher the number of vacant spaces indicated for the chosen car park the greater will be the reduction in estimated wait time. The PGI information apparently has more impact on females' expected wait times than on those of males.

The subject's own initial expectation of probable wait time (*InExpPWT*) has a very significant influence - the larger the initial expectation the lower the increase in expectation. This 'compensation' effect, which is most marked for females, suggests a regression to the mean which probably reflects a tendency to expect wait times within a reasonable range whatever the PGI says (thus an initially high expectation cannot be increased as much as an initially low one). The *Shop* dummy indicates that the extra wait time associated with shopping trips is further reinforced, particularly for females, when the expectation is revised after seeing PGI. Unsurprisingly, the pre-trip information does not have a significant influence on the change.

The finding from EW4 that PGI has more influence on females' than males' expectations of wait time is interesting when compared to the finding from model R4, which suggests that females' choices of car park are less influenced by PGI. It appears that, although females take more notice of PGI in their estimates of wait times, their eventual choice of car park is even more influenced by other factors.

.   CONCLUSIONS AND FURTHER WORK

4.1 Conclusions on the Models

The development of models for application in CONTRAM was constrained to exclude variables which would not be available within a CONTRAM environment. Models I1, R3, E5 and S1 were deemed to be the best models from PARKIT data which met this constraint. These models provided a good explanation of the data but were not as successful in this respect as those models which utilised more of the disaggregate and lagged information available within PARKIT.

The link between expectation and choice is clearly not straightforward. The EW models are interesting but clearly do not provide a complete explanation of drivers' expectations of wait times.

4.2 Conclusions on PARKIT as a Source of Data for Analysis of Parking Behaviour

The results have demonstrated that PARKIT produced data with which to estimate the effect on route choice and car park choice of conventional variables such as journey time and cost as well as of less widely modelled variables such as the information provided on PGI signs, and the different contributions of drive time, walk time and queuing time. Furthermore, because PARKIT allowed subjects to experience the consequences of different choices and to report their impressions, we have been able to explore issues such as learning, habituation, anticipation, intention and the dynamics of an evolving decision.

Naturally, the calibrated values of the behavioural coefficients reflect the attributes of the network and parking stock in which the behaviour was observed (in our case this is the PARKIT network shown in Figure 2b) and, except where the models include separate coefficients for people with different characteristics, the characteristics of the observed population of drivers. A particular strength of the PARKIT approach is that these influences are not hidden, as they often are in data derived from observing behaviour in "real" networks, and may be identified by appropriate experimental design.

The richness of the PARKIT database and the high degree of experimental control afforded to the analyst, allowed examination of issues such as habituation of behaviour and the impact of prior knowledge which are difficult or impossible to address with more conventional data sources.

Almost all the PARKIT subjects claimed to have behaved in the PARKIT environment as they would have done in the real world (data from those not making this affirmation were excluded from the analysis). This claim would seem to be supported by the intuitively reasonable values derived for most of the behavioural coefficients in the modelling work. However a concern remains that PARKIT subjects perhaps took less notice of price than might be expected. This may be because, while they were made to suffer the time consequences of their choices (eg having to wait while their car was queuing to enter a car park), they did not have to pay the parking charges out of their own pocket. There is an obvious potential solution – namely to deduct any charges they incur from a participation fee. This approach was indeed used by the authors in their previous work on road user charges although, as discussed in Bonsall (2002), it is not without difficulties.

Another concern with the current work is whether the representation of prior knowledge via briefing sheets such as those in Figures 2a and 2b is adequate. As was noted in section 3.6.4, the behaviour of unfamiliar drivers reflected the "knowledge" contained in Figure 2a. It may be that this characterisation of a newcomer's knowledge would not be appropriate for those drivers who would not dream of setting off on a journey without precise instructions on how to reach the destination by car and on the location of the nearest car park. We would certainly not wish to suggest that Figure 2a, or any other single characterisation of restricted knowledge, is appropriate for all drivers and, in an ideal experiment, would wish to explore the effect of allowing for different patterns of unfamiliar drivers' knowledge. One approach might utilise the subjects' actual knowledge of a real city but this would require a survey of current knowledge and considerable loss of experimental control.

The experimental protocol outlined in Table 1 seeks to present the software, familiarise the user with its use and then use it to explore a range of issues connected with network knowledge, learning and experience - all within a 45 minute session. This may be thought to be a trifle ambitious and some would question whether, using such a protocol, we can really expect the subjects to be responding in a realistic manner to the stimuli presented. We cannot, of course, prove that the behaviour exhibited in PARKIT is representative of that in the real world, but we can draw some comfort from the subjects' own assertions that they were behaving as they would in the real world, from the fact that the behaviour is intuitively reasonable and from the fact that, when behaviour in a comparable simulator, VLADIMIR, was painstakingly compared with that in real life, the fit was very impressive (see Bonsall *et al*, 1997).

Having now used data from the PARKIT simulator, we conclude that it is a very powerful tool for the investigation of parking behaviour. The fact that PARKIT runs on a PC made it possible to take the tool to the subjects rather than requiring the subjects to visit a research office or laboratory. This facilitated achievement of a large and representative sample of subjects. Although the presence of an interviewer was not strictly necessary (thus allowing savings in cost and removal of a potential source of bias), it was in practice convenient to have survey staff on hand to administer the session and record their impressions of how the subject performed. A typical PARKIT session lasted around 45 minutes – which was long enough for the subject to get into the spirit of the exercise but not so long as to risk respondent fatigue.

In conclusion, PARKIT appears to have been well received by subjects and survey staff and the resulting data appears to be sound and to reflect a number of interesting facets of behaviour and perception relevant to parking choice behaviour and to responses to information. The flexibility offered by PARKIT offers the possibility of exploring a very wide range of issues.

4.3 Further Work

This paper has highlighted that further work could be undertaken in the statistical modelling of parking choices, the factors affecting the parking environment and the development of the PARKIT tool itself.

Our work has raised a number of statistical modelling issues which could usefully be further explored. These include:

- the use of lagged variables to represent the (reducing) impact on exit choices of decisions made, and PGI information received, at earlier stages of the journey - it is recognised that this may require a move away from the standard logit approach.
- alternative nesting structures and the flexibility offered by Mixed Logit;
- the extent to which PARKIT has been able to capture any tendency of drivers to prefer near-side turns over off-side turns.

PARKIT was written such that the details of the simulated world, the journeys, the questions and the dialogues can be altered by the experimenter. This flexibility allows the software to be configured to study a wide range of parking-related choices. Potentially influential aspects of the parking environment which could be further explored in PARKIT, include:

- representing a spectrum of levels of network familiarity rather than simply dividing the population into those who are "unfamiliar" and those who are "familiar" – similarly it would be interesting to explore the effect of different characterisations of the knowledge possessed by unfamiliar drivers;
- allowing subjects to get lost in the network. This could perhaps be achieved by having a more complex network, less meaningful street names, no compass, and no detailed map but the exercise would then really becomes a route choice experiment for which VLADIMIR might be better suited than PARKIT;
- further investigation of the effect of the accuracy of PGI information on drivers' response to it – continuing the work begun by Lai (1997); and

- investigating the influence of supply variables (network layout, parking stock, congestion patterns, etc) on the specification and generalisability of the resulting models.

Aspects of PARKIT which would benefit from further research include:

- testing the sensitivity of the results to the multipliers used to represent the passage of time while engaged in different elements of a journey (the values of in-vehicle time and walking time derived from the coefficients of our models suggests that the representation of walking used in our PARKIT work was not inappropriate but a question remains as to whether the result was due to the higher fraction of real time or to the deliberately tedious nature of the screens displayed during the walk phase of a journey);
- exploring different ways of expressing the risk of having to queue at car parks; and
- testing the effect of requiring simulator subjects to part with real money when “paying” a parking charge.

Acknowledgements

We are pleased to have this opportunity to acknowledge the financial support of the UK Engineering and Physical Sciences Research Council for the development of PARKIT and to thank colleagues in Leeds, London and Southampton for their contribution to discussions during the development of PARKIT, to the conduct of the surveys and to the initial analysis of the dialogues. Particular thanks in these respects are due to Peter Balmforth (who programmed the PARKIT software), and to Mario Alves, Kiron Chatterjee, Paul Firmin, John Polak, Caron Roach, Russell Thompson and Di Wofinden.

Appendix 1: Definition of variables used in models

Parameter	Long Name	Description
Drive	Drive time	Minimum drive time to a car park via this exit (in minutes)
Vis-wait	Visible queue	Extent of queuing outside a car park that could be seen by the driver (translated, via the queue dissipation rate, into minutes of queuing)
Price	Price of Parking	The price in pence to park at a car park - for the duration of stay specified in the pre-trip briefing information
Walk	Walk time	The time required to walk (at a 5 kph) from a car park to the final destination (in minutes)
Full	PGI sign says FULL	Dummy variable for a car park, set if the driver has passed a PGI sign saying that the car park is "FULL"
#Spaces	Number of spaces	The number of parking spaces available at a car park as displayed on the most recent PGI sign passed by the driver
#Spaces2	No. of spaces squared	The square of *#Spaces (#Spaces2* is used in conjunction with *#spaces* to explore non-linearities in the influence of the number of spaces, e.g. a positive coefficient on *#spaces* combined with a negative coefficient on *#spaces2* would suggest a positive but decreasing function)
ExpDel	Prob of expected wait of 5 minutes	The probability of having to wait more than 5 minutes at a car park. ("prior information" given on the pre-trip information sheet)
ExpDel0 *ExpDel5* *ExpDel10* *ExpDel20* *ExpDel50*	chance of waiting more than 5 minutes is X% (X = 0, 5, 10, 20 or 50)	Dummy variables for a car park, set when the probability of having to wait more than 5 minutes is X ("prior information" given on the pre-trip information sheet)
ExpDelLE5	chance of waiting more than 5 minutes is no more than 5%	Dummy variable for a car park, set when there is no more than a 5% probability that the wait to enter the car park will exceed 5 minutes ("prior information" given on the pre-trip information sheet)
InExpPWT	Initial expectation of probable wait time	Subject's initial expectation of the probable wait time at the car park (from dialogue questions)
Passed	Car Park has been passed	Dummy variable for a car park, set if driver has already passed the car park on the current journey.
Intended	Intended car park	Dummy variable for a car park, set if the driver indicated, prior to the journey, that this was the car park he was heading for
LastCP	Last car park used	Dummy variable for a car park, set if it was used by the driver in his/her immediately previous journey
Shop	Shopping trip	Dummy variable for trip context, set to 1 if the trip is a shopping trip, otherwise zero.
Park	Whether the exit leads to a car park	Dummy variable for an exit, set to 1 if it leads directly into a car park, otherwise set to zero
ThetaE	Log sum for an exit	Scale parameter for the log of the sum of the utilities for car parks assigned to an exit at a decision point.
Theta1	Log sum for High St	Scale parameter for the log of the sum of the utilities for the High St car parks
Theta2	Log sum for City Centre	Scale parameter for the log of the sum of the utilities for the city centre car parks
Theta3	Log sum for parking	Scale parameter for the log sum of the utilities for any visible car parks at a decision point

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Figure 1: Various PARKIT screens showing driver's-eye view of progress of journey (black and white versions of colour originals)

1a: driving along a link

1b: approaching a PGI sign junction

1c: arriving at a car park

1d: searching for a space inside a car park

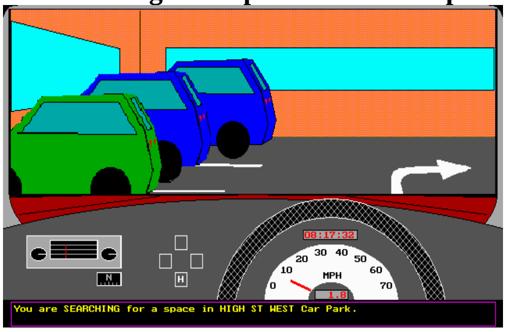
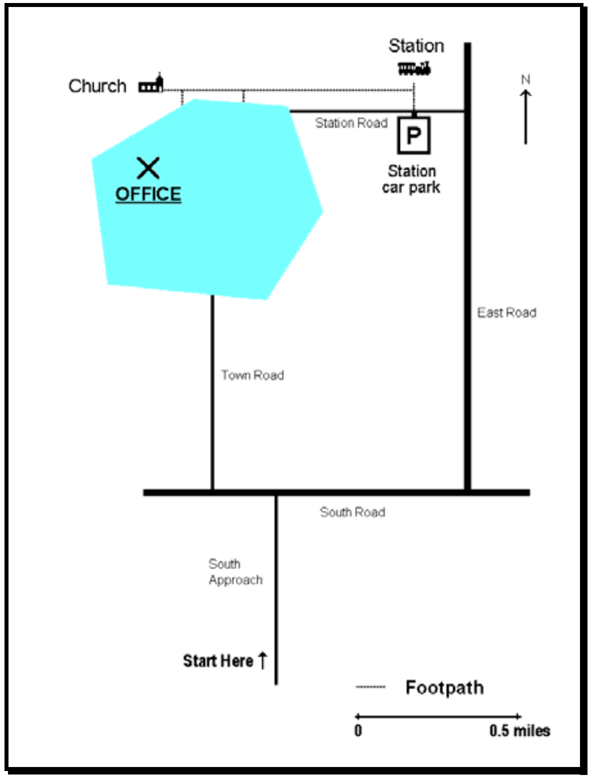


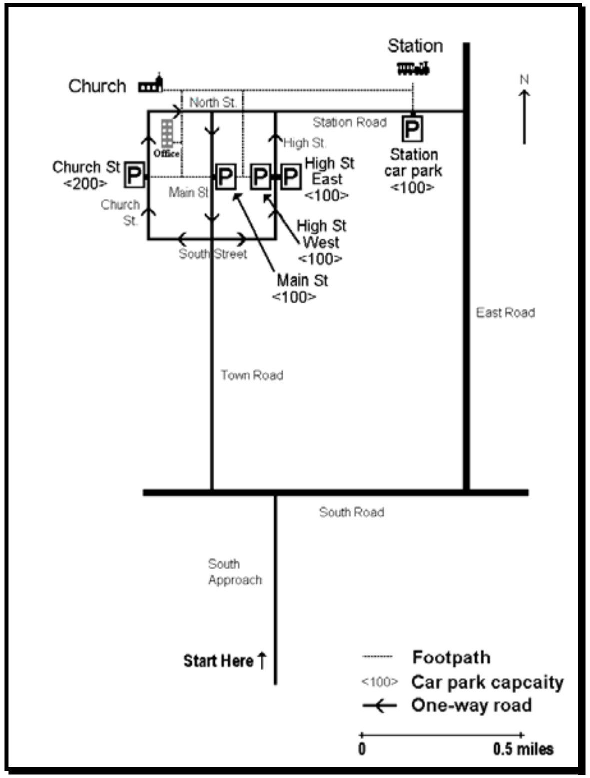
Figure 2 Pre-trip Briefing Sheets (reduced from A4 sized originals).

Figure 2a:.representing minimal prior knowledge



CAR PARK NAME	*Risk of having to wait more than 5 minutes*		PARKING FEE (£)
Station Road	Nil	0%	1-00
Town Centre	?	?	?

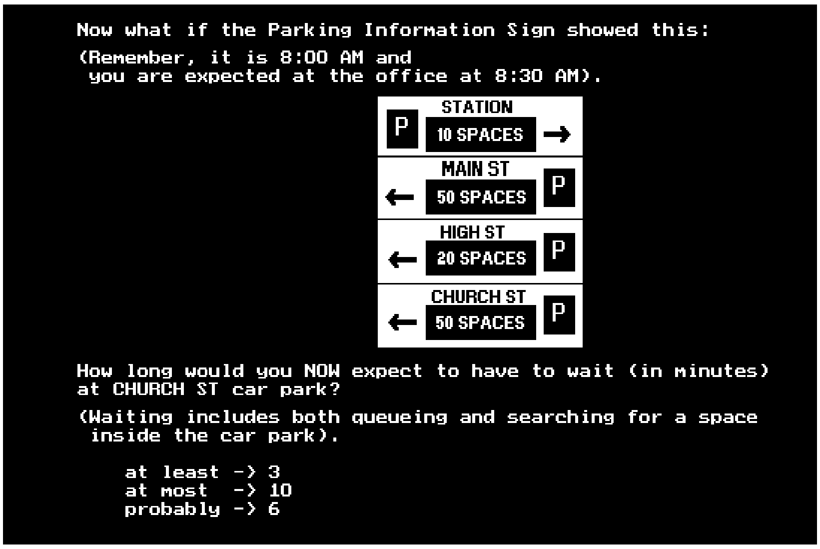
Figure 2b:.representing substantial prior knowledge



CAR PARK NAME	*Risk of having to wait more than 5 minutes*		PARKING FEE (£)
Church St	1 in 5	20%	2-50
Main St	1 in 10	10%	5-00
High St West	1 in 10	10%	2-50
High St East	1 in 2	50%	5-00
Station Rd	Nil	0%	1-00

Figure 3: Question and Dialogue Screens from PARKIT

3a: question screen



3b: dialogue screen

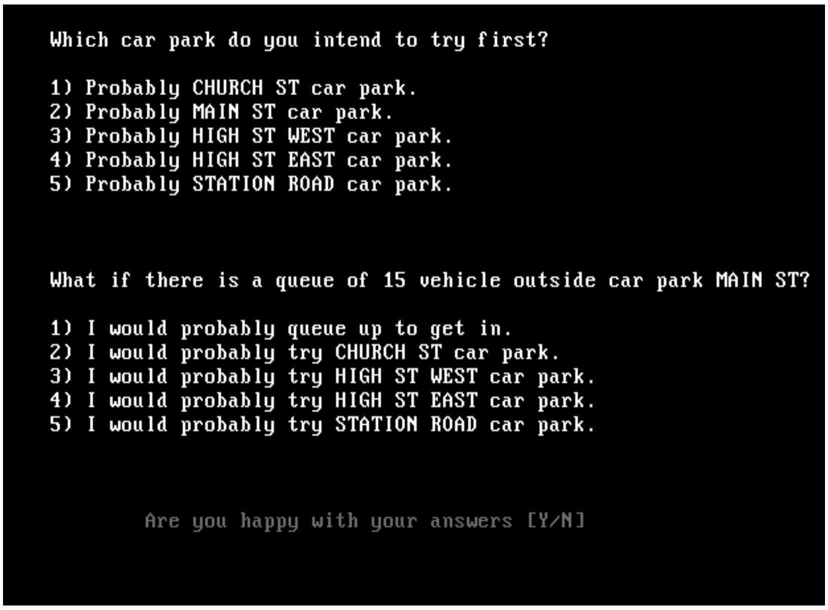


Figure 4: Model Structures

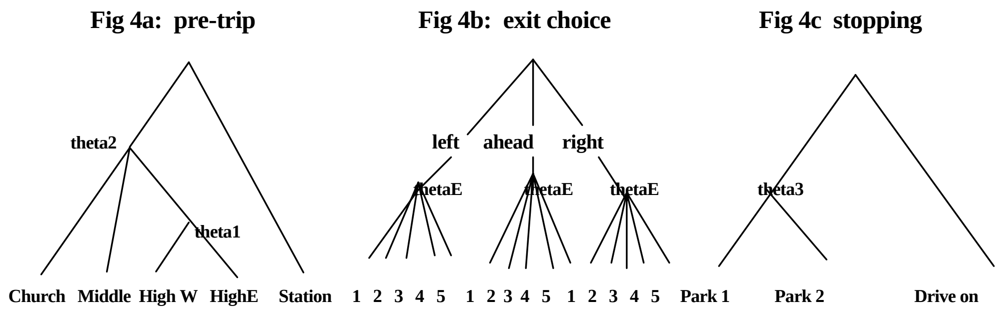


Table1: Summary of Experimental Design

Introduction	screens explaining PARKIT and what was expected of the subject
Training journey	training journey in a simple network.
Journey 1	journey in an unfamiliar network- using figure 2a (PGI provided for half the subjects)
Journey 2	repeat J1, but with fuller information – as per map in figure2b and one of three tables of wait-risks and prices. (i.e. subject now classed as a familiar driver)
Journey 3	network and stock still as per map in figure 2b but with different table of wait-risks and prices (change in car park prices **or** in risk of having to wait)
Journey 4	repeat J3 with the introduction of PGI for second half of subjects as well
Journey 5	repeat J3 with severe congestion in city centre car parks
(note that the queuing patterns experienced in a 'repeat' journey will always differ slightly from its predecessor)	
Dialogues	2 sets of 3 PGI dialogue questions

Table 2: Tabulation of behaviours apparent in the PARKIT data

Journey number	Number of people who											
	said they intended to head for city car parks						said they intended to head for station car park					
	and did park in a city centre car park			but parked in the station car park			but parked in a city centre car park			and did park in the station car park		
	No PGI	PGI		No PGI	PGI		No PGI	PGI		No PGI	PGI	
1	**37**	**23**		**1**	**4**		**0**	**10**		**39**	**22**	
2	**55**	**50**		**4**	**4**		**0**	**1**		**16**	**6**	
3	**35**	**32**		**3**	**8**		**0**	**3**		**33**	**21**	
		S/F	**#spaces**		**S/F**	**#spaces**		**S/F**	**#spaces**		**S/F**	**#spaces**
4	**-**	**37**	**52**	**-**	**1**	**1**	**-**	**2**	**1**	**-**	**25**	**14**
5	**-**	**22**	**42**	**-**	**22**	**9**	**-**	**1**	**0**	**-**	**19**	**15**

S/F = PGI shown as "Spaces" or "Full", #spaces = PGI messages shown as number of spaces available

Table 3: Model of the initial choice of car park, prior to beginning journey

	I1		I2		I3	
	Param	**t-stat**	**Param**	**t-stat**	**Param**	**t-stat**
Price	-0.0050	-9.4	-0.0049	-8.8		
Under £50k					-0.0050	-8.4
Over £50k					-0.0055	-2.9
Walk	-0.0783	-7.2	-0.0771	-6.6		
Under £30k					-0.0638	-4.8
£30-50k					-0.0940	-5.1
£50k+					-0.2009	-4.0
LastCP	1.2410	14.0	1.1539	12.1		
Under £15k					1.9240	7.5
£15-30k					1.0840	8.1
Over £30k					0.7978	4.8
ExpDelLE5	0.3842	3.4	0.3059	2.6		
Office trip					0.5269	3.4
Shop trip					0.0210	0.1
Likelihood initial / final	-943 / -747		-817 / -666		-817 / -648	
Rho-sq zero / cost	0.21 / 0.17		0.19 / 0.15		0.21 / 0.18	
No. of obs	586		508		508	

Table 4: Models of revised choice – after pre-trip PGI

	R1		R2		R3		R4	
	Param	**t-stat**	**Param**	**t-stat**	**Param**	**t-stat**	**Param**	**t-stat**
Price	-0.0026	-4.1	-0.0027	-4.6	-0.0027	-3.7		
Under 30							0.0006	0.5
30 to 50							-0.0029	-3.5
Over 50							-0.0050	-3.8
Walk	-0.0297	-1.6	-0.0349	-1.9	-0.0432	-2.5	-0.0464	-2.6
Intend	2.2030	12.8	2.1220	12.7	2.2500	16	2.3150	16.0
ExpDel	-0.0062	-1.3						
ExpDelLE5			0.4043	2.2	0.2800	1.7	0.2492	1.5
FULL	-2.6730	-9.6	-2.6520	-9.5	-2.6210	-9.5		
Female							-2.3101	-5.7
Male							-2.9802	-7.9
# SPACES	0.0326	3.8	0.0331	3.9	0.0337	3.9		
Female							0.0219	1.8
Male							0.0485	4.0
# SPACES2	-0.0016	-2.8	-0.0002	-2.9	-0.0002	-2.8		
Female							-0.0001	-1.0
Male							-0.0002	-3.0
Theta1	1.112	7.7	1.158	8	1	n/a	1	n/a
Theta2	1.133	4.7	1.216	5.4	1	n/a	1	n/a
Likelihood initial /final	-401 / -346		-406 / -344		-406 / -345		-735 / -337	
Rho-sq zero / const	0.53 / 0.41		0.53 / 0.41		0.53 / 0.41		0.54 / .42	
No. of obs	378		378		378		378	

Table 5: Exit Choice Models for En-route Decisions

	E1		E2		E3		E4		E5		E6	
	Param	**t-stat**	**Param**	**t-stat**	**Param**	**t-stat**	**Param**	**t-stat**	**Param**	**t-stat**	**Param**	**t-stat**
Drive	-0.469	-6.1	-0.529	-8.6	-0.536	-7.0	-0.472	-8.2	-0.362	-5.5	-0.326	-6.0
Viswait	-0.471	-4.0	-0.845	-6.4	-0.548	-5.0	-0.471	-5.6	-0.631	-5.4	-0.553	-6.0
Full	-0.616	-2.5	-0.713	-3.6	-0.729	-3.1			-0.774	-3.4		
Under £30k							-0.768	-2.5			-0.796	-2.6
£30-50k							-1.841	-3.8			-1.812	-3.8
Over £50k							0.043	0.1			-0.048	-0.1
# Spaces	0.040	5.2	0.018	2.9	0.043	5.8	0.039	5.5	0.038	5.3	0.035	5.1
# Spaces2	-0.0001	-2.9	-0.0001	-1.6	-0.0002	-3.4	-0.0001	-3.0	-0.0001	-3.0	-0.0001	-2.8
Passed	-2.741	-3.5			-1.910	-3.0	-1.732	-3.3	-1.736	-2.9	-1.638	-3.2
Intended	3.323	6.4			2.542	7.1			2.349	7.3		
Under 50							2.115	8.1			1.985	8.2
Over 50							2.574	7.4			2.426	7.6
Price			-0.009	-6.1	-0.004	-4.1			-0.004	-4.4		
Office							-0.002	-2.3			-0.002	-2.8
Shopping							-0.004	-4.8			-0.005	-5.0
Walk			-0.171	-6.2	-0.118	-5.5			-0.105	-5.1		
Female							-0.130	-6.2			-0.120	-5.8
Male							-0.084	-4.6			-0.073	-4.1
Park									1.316	3.7	1.158	3.8
ThetaE	0.584	6.0	0.664	7.5	0.691	6.8	0.804	7.8	0.732	6.9	0.836	7.9
Likelihood initial/final	-3182 / -960		-3182 / -1165		-3182 / -931		-3182 / -916		-3182 /-.922		-3182 / -907	
Rho-sq zero / const	0.70 / 0.35		0.63 / 0.21		0.71 / 0.37		0.71 / 0.38		0.71 / 0.38		0.72 / 0.39	
No. of obs	1977		1977		1977		1977		1977		1977	

Table 6: Stopping Model for Unfamiliar Drivers

	S1		S2	
	Param	**t-stat**	**Param**	**t-stat**
VisWait	-1.5437	-1.7		
Female			-2.2766	-2.0
Male			-1.2696	-1.7
Price	-0.0134	-3.7	-0.0139	-3.6
Park	3.5048	5.5		
Office trip			4.3282	5.4
Shopping trip			3.1185	4.7
Theta3	0.2826	1.6	0.2587	1.7
Likelihood initial / final	-143 / -72		-143 / -68	
Rho-sq zero/ const	0.50 / 0.29		0.52 / 0.32	
No. of obs	175		175	

Table 7: Regression Models of Expected Wait Times (mins)

7a Estimate of most probable wait time

	EW1		EW2female		EW2male	
	Param	***t-stat***	***Param***	***t-stat***	***Param***	***t-stat***
Intercept	5.284	7.9	5.758	5.1	5.148	7.2
ExpDel	0.102	4.1	0.118	3.1	0.068	2.4
Shop	1.144	1.4	1.607	1.2	0.302	0.3
Multiple R	0.36		0.40		0.298	
Adjusted R Square	0.12		0.13		0.05	
Observations	132		66		67	

7b Change in estimate of change in wait time (mins) after seeing PGI

	EW3		EW4Female		EW4Male	
	Param	***t-stat***	***Param***	***t-stat***	***Param***	***t-stat***
InExpPWT	-0.489	-6.9	-0.571	-7.2	-0.268	-1.9
Intercept	5.237	7.1	4.502	4.7	5.058	4.3
ExpDel	0.006	0.3	0.020	0.8	-0.011	-0.3
Shop	0.322	0.5	1.625	1.8	-0.663	-0.6
#spaces	-0.030	-2.3	-0.034	-2.1	-0.028	-1.4
Full	3.314	3.9	3.780	3.3	3.115	2.5
Multiple R	0.51		0.62		0.36	
Adjusted R Square	0.25		0.36		0.10	
Observations	266		132		134	