

Broadcast Parking Information: Behavioral Impacts and Design Requirements

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For the past 2 years Nottinghamshire County Council, in collaboration with local radio stations, has been running an experimental broadcast parking information service during the Christmas period that provides drivers with up-to-the-minute information on occupancy, queues, and parking alternatives. The results of a study designed to investigate the impact of the service on motorists' travel and parking behavior are presented. The study involved a mail-back survey distributed to drivers at city center parking lots, on-street parking areas, and peripheral park-and-ride sites. The results of the study indicate that awareness of the service is high but that its impact on parking behavior is more limited. Although substantial use is made of the service by drivers en route to the city center, there is little evidence that this mode of use results in any significant impact on parking behavior or experienced search and queueing time. By contrast, the minority of drivers who use the broadcast service at the pretrip stage on average enjoy significantly reduced search and queueing time and are more likely to divert to park and ride. Drivers' tolerance of searching and queueing and the nature of their knowledge of parking alternatives are important factors conditioning the use and impact of the broadcast service.

In European cities, congestion associated with searching or queueing for parking spaces is a large part of the overall level of urban congestion. Recent studies of parking behavior in five British and German cities found that on average between 10 and 25 percent of total in-vehicle time is occupied in searching or queueing for parking (1). These empirical findings are reinforced by simulation studies carried out by Hoffmann that indicate that reductions in travel times of up to 20 percent could be achieved by more efficient routing of vehicles to parking lots (2).

Parking congestion can arise for a variety of reasons, including local inefficiencies in road layout, poor parking lot design, and drivers' lack of awareness of prevailing levels of occupancy in key parking lots or alternative parking and travel opportunities. In the latter case, systems designed to provide travelers with improved information on the parking system have the potential to reduce parking congestion by enabling the more efficient use of existing capacity. In Europe there is considerable interest in the scope for advanced parking management systems based on in-vehicle, roadside, and broadcast information (3).

Although the potential impact of such systems is substantial, their success will depend crucially on how travelers acquire, use, and respond to the provided information. A grow-

ing body of work highlights the need for improved understanding of the behavioral impact of traveler information systems, both as an input to the system design process and as a requirement for comprehensive evaluation (4,5).

This paper presents the results of a study into the behavioral impact of a broadcast parking information system that has operated for the past 3 years in the city of Nottingham. The system operates during the Christmas period and is based on local radio broadcasts providing drivers with up-to-date information on parking lot occupancy, queue lengths, and alternative parking opportunities.

BACKGROUND

Motivation

Nottingham experiences an abrupt and substantial increase in traffic volume and parking lot occupancy in the 10 to 12 weeks before Christmas. Traffic flows increase by 10 to 15 percent over their level in an average month, and the average midday occupancy in city center multistory parking lots increases from 75 percent in June to 93 percent in December. Long queues develop regularly outside the most popular city center parking lots and have become a significant source of inconvenience and delay. Sometimes these queues extend as far as 300 m, reducing the capacity of upstream junctions and causing increased congestion and accident risk to general traffic. Experience has shown that conventional methods of regulation and enforcement (e.g., increased police and warden activity) are of only limited effectiveness in combating queueing. Moreover, such measures can only address the problem once it has occurred rather than prevent it in the first place.

Despite the severity of the queueing problem at the most popular parking lots, studies carried out by the county council have shown that even in periods of peak parking demand, up to 500 spaces can be available in other (less popular) city center parking lots, in addition to up to 3,600 spaces at four (two daily and two Saturday only) park-and-ride sites. Therefore, there appeared to be scope for reducing the problems of parking congestion in the center of Nottingham if motorists could be encouraged to make more use of this existing but underused capacity.

Broadcast Information Service

The aim of the broadcast information service was to help drivers to avoid spending long periods searching and queueing

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at the most congested parking lots by providing information to encourage them to divert to less crowded city center parking lots or use the park and ride. The service operated from the beginning of October to the middle of January between 9:00 a.m. and 1:00 p.m., Monday through Saturday, and involved close cooperation between Nottinghamshire County Council and two local radio stations, Radio Nottingham and Trent FM. Information was presented in a fixed-format message of 1 to 2 min and delivered three times an hour on Radio Nottingham and twice an hour on Trent FM. Each message consists of four components:

- A list of parking lots with queues and the estimated queueing times,
- A list of parking lots with spaces available,
- Current occupancy status of all park-and-ride sites, and
- Two or three pieces of "helpful advice" at the presenter's discretion from a list supplied by the county council.

The information on parking lot queues was provided by the highway authority by means of closed-circuit television monitoring of the entrances of all key parking lots. The observed queue lengths were used to estimate expected queueing times, using the results of a survey of queueing times at the most popular parking lots during the morning peak parking periods that was carried out before the service was introduced. The parking lot information was collated and presented by a member of staff of Radio Nottingham stationed in the Urban Traffic Control Center. The availability of the service was advertised by roadside signs placed on all the main radial roads entering Nottingham.

BEHAVIORAL IMPACT STUDY

Objectives

The main objective of the study was to investigate drivers' awareness and use of the broadcast information service and to determine its impact, at an individual level, on their parking behavior and experienced parking outcomes. Given the emphasis of the service on providing improved information, there was a particular concern to explore the role played by drivers' prior knowledge and experience of local parking circumstances in conditioning their use of and response to the service.

Methodology

The survey was carried out over a 3-week period starting at the end of November 1990 and involved a combination of on-street personal interviews and mail-back surveys. This approach enabled a large sample of travelers to be contacted to establish awareness and use of the service by different groups while also providing the scope for a more detailed exploration of behavioral factors and impacts.

The initial contact interview collected basic journey and personal details and brief information about drivers' awareness and use of the information service, in general and on the

specific day of interview. To contact a sample of drivers with a range of parking preferences and experiences, interviewing was carried out at a selection of city center parking lots, park-and-ride sites, and on-street parking locations. Recruitment was restricted to individuals who had driven into Nottingham on the survey day and who did not have access to private or reserved parking facilities. Quota sampling was used to ensure adequate representation of all relevant categories of journey purpose, parking type used, and planned duration of stay. As a result of the sampling and quota procedures used in recruitment, the contact sample is not necessarily representative of the characteristics of all travelers to Nottingham. Respondents who completed the initial contact interview were given a stamped envelope containing a longer mail-back questionnaire, structured in four sections.

The first section collected a more detailed description of the journey being made at the time of interview, focusing in particular on the way in which they searched for a parking place and their parking preferences, since these were considered likely to be significant factors in conditioning traveler response to the broadcast information.

The second section of the mail-back questionnaire investigated travelers' knowledge of parking conditions in Nottingham, using a map showing the nine major city center parking lots included in the broadcast service. Drivers were shown the map and asked to indicate whether they knew about, had ever used, and could name each parking lot (Figure 1). This device furnished insight into the range of drivers' experiences of different parking lots and their perceptions of their own knowledge of parking and, importantly, enabled the contrast of these perceptions with a relevant objective measure of parking knowledge.

The third section of the mail-back questionnaire explored drivers' attitudes toward the broadcast information service and the effect of the service on travel and parking behavior, including the choice of mode and journey timing.

The final section focused on attitudes toward possible extensions and enhancements of parking information services and is not discussed in this paper.

RESULTS

Sample Characteristics

A total of 1,584 car drivers were contacted in the initial on-street interviews, of which 627 returned the mail-back questionnaire, a response rate of almost 40 percent. More than 70 percent of the sample consists of shoppers arriving during the period of peak parking lot occupancy between 9:00 a.m. and 1:00 p.m. and staying for fewer than 4 hr. Almost half the sample visited the city by car once or more a week, and almost 30 percent visited less than once a month. The overwhelming majority of the less frequent visitors were engaged on shopping journeys, many specifically associated with Christmas. Almost 90 percent of respondents parked off the street either in city center multistory parking lots (49 percent) or at park-and-ride sites (40 percent). On-street parking was used mainly by those visiting the city on personal or employers' business and staying for fewer than 2 hr.

B.5 Below is a map of the central area of Nottingham showing several of the major car parks. Next to each car park is a panel in which we would like you to tell us

- If you previously know about this car park, (IF SO THEN TICK THE "KNOWN" BOX)
- if you have ever used it (IF SO THEN TICK THE "USED" BOX)
- what name you would use to refer to it [WRITE IN THE NAME IN THE SPACE PROVIDED].

The map shows the central area of Nottingham with various streets and landmarks. Nine car parks are marked with 'P' in a square. Each car park is connected by a line to a survey panel. The survey panels are arranged in two rows: four at the top and five at the bottom. Each panel contains a 'Known' box, a 'Used' box, and a 'Name known by' field.

Streets shown on the map include: DERBY RD, WOLLATON ST, BURTON ST, MILTON ST, GLASSHOUSE ST, UPPER PARLIAMENT ST, LOWER PARLIAMENT ST, GRANDBROOK ST, BELFORD ST, LONDON ROAD, STATION ST, QUEENS ROAD, SHERIFFS WAY, CARINGTON ST, CANAL ST, WILFORD ST, CASTLE BOULEVARD, CASTLE ROAD, MARIAN WAY, CASTLE GATE, HIGH PAYMENT, ST PETERS GATE, OLD MARKET SQ, VICTORIA ST, FLEETTER GATE, LAKE, MOUNT ST, MAID, PARK ROW, GENERAL HOSPITAL, NOTTM CASTLE, BROADMARSH SHOPPING CENTRE, COLLIN ST, NOTTM STATION, VICTORIA SHOPPING CENTRE, TRINITY SQ, ROYAL CONCERT HALL, THEATRE ROYAL.

FIGURE 1 Map shown to drivers of nine major city center parking lots included in broadcast service.

Awareness and Use of Broadcast Service

Figure 2 summarizes the results concerning awareness and use of the broadcast service. Sixty-three percent of the drivers in the sample were aware of the broadcast service. As expected, awareness of the service was strongly related to local radio listening behavior: 92 percent of regular listeners were aware of the service, but only 56 percent of those listening occasionally or not at all were aware of it. Awareness was also related to the frequency of parking in Nottingham: 68 percent of those parking more than once a month were aware of the

service compared with only 51 percent of those parking less frequently ($\chi^2 = 35.6, p < .0001$). This finding is to be expected because frequent travelers will receive greater exposure to efforts to promote the service.

Among personal factors, age has the only significant effect: 65 percent of those between 25 and 45 were aware of the service compared with only 55 percent in the younger or older groups ($\chi^2 = 12.9, p < .005$). This probably reflects the age profile of the listening audience of the local radio stations, although no independent data were available to confirm this. Most of the respondents who were aware of the service first

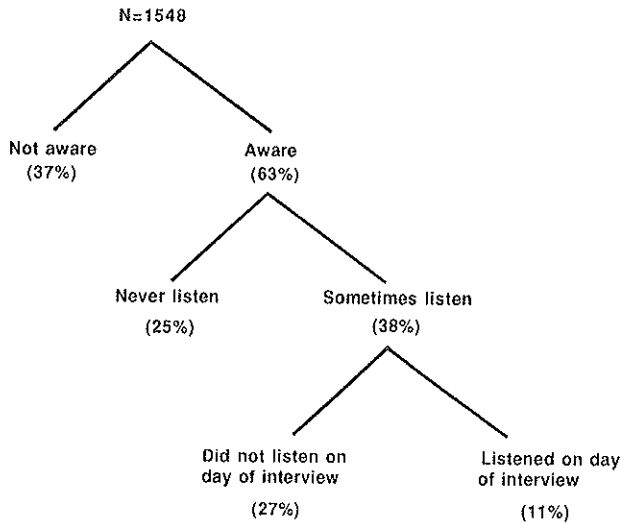


FIGURE 2 Pattern of awareness and use of broadcast service.

learned about it either by listening to the radio (32 percent) or by seeing the roadside signs advertising the service (23 percent); word of mouth (5 percent) was the only other significant method of dissemination.

Of those aware of the service, 56 percent claimed to have used it, which represented 38 percent of the total sample. Radio listening behavior was again a major conditioning factor, with more than 80 percent of regular listeners (who were aware of the service) claiming to use it, compared with only 32 percent of occasional listeners. Frequent travelers also made much greater use of the service (59 percent versus 48 percent for infrequent travelers, $\chi^2 = 8.3, p < .004$).

Users of the service tend to be selective, with only 18 percent deliberately tuning in to the service every time they travel to Nottingham during the Christmas period. Another 23 percent tune in only when traveling on a day or at a time when they expect to encounter serious parking congestion. The remaining 69 percent of users attend to the information only if they happen to hear it on the radio. Just over 28 percent had listened on the day of interview, which was 11 percent of the total sample.

Most (74 percent) of those who listened to the broadcast service on the day of interview first did so in their vehicles en route to the city center. However, a significant proportion of drivers used the service at the pretrip stage, and there was a marked difference in listening behavior according to the type of parking used: those using park and ride were much more likely to have first used the broadcast service at home ($\chi^2 = 11.4, p < .001$):

Type of parking used	When first listened to service (%)	
	Pretrip	En Route
City center (N = 87)	16	84
Park and ride (N = 61)	41	59

Those who actively seek information from the service are also much more likely to listen at the pretrip stage or to combine pretrip and en route listening ($\chi^2 = 12.1, p < .06$).

Two factors appeared to be responsible for the decision of drivers who were aware of the service not to use it. The most common explanation (cited by more than 45 percent of such nonusers) was that they believed themselves able to find a parking space without assistance. In addition, just over 40 percent did not listen to the relevant local radio stations and although aware of the broadcast service did not want to retune their receiver. Only 4 percent of deliberate nonusers stated that they had tried the service but found the information not useful or unreliable, confirming the general pattern of satisfaction among users of the service.

Parking Search and Queuing Behavior

Characteristics of Existing Behavior

Figure 3 shows the variation throughout the day in the time that drivers reported they spent searching and queuing for different types of parking.

Average search and queuing times at multistory parking lots increase sharply after 10:00 a.m., reaching a peak of almost 20 min near midday and diminishing rapidly thereafter. A similar pattern of variation is evident in the time spent searching for on-street parking, although the peak is reached earlier and the absolute level is lower. Overall, drivers using city center multistory facilities spend an average of 5.0 min searching and queuing for parking, which, at an individual level, accounts for between 10 and 21 percent of their total journey time. Those using city center on-street parking spend significantly longer searching ($F = 21.92, p < .0001$), but when queuing time is taken in account, they experience less overall delay in parking. As expected, those using park and ride report insignificant amounts of search and queuing time.

Besides asking respondents how long they had actually searched or queued for parking, the survey also collected information about how long they were prepared to search and queue before seriously considering giving up. Across the sample the average search and queuing "budget" was 12.9 min,

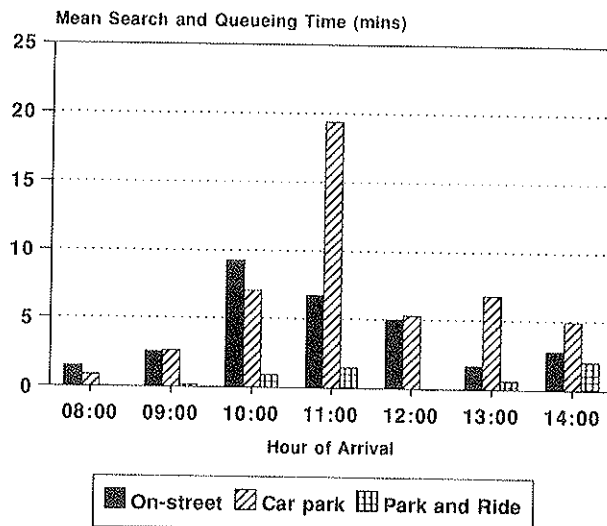


FIGURE 3 Mean search and queuing time by time of arrival.

and an analysis of variance revealed significant variations according to journey purpose ($F = 10.79$, $p < .01$) and type of parking chosen ($F = 40.5$, $p < .0001$):

Factor	Budget (min)
Journey purpose	
Commute	9.0
Shopping	12.8
Other	15.1
Chosen parking	
On street	18.8
Multistory lot	16.5
Park and ride	7.1

It appears therefore that drivers' tolerance of search and queueing is conditioned by the characteristics of the journey and is itself an important factor in conditioning the choice of parking. In particular, the evidence suggests that during periods of parking congestion, park and ride tends to attract those with a relatively low tolerance of search and queueing and that, conversely, most of those who choose to park in the city center during such periods are willing to spend considerable time searching and queueing for parking.

Impact of Broadcast Service on Search and Queueing Time

To determine whether drivers using the broadcast service derive any real advantage in terms of reductions in their search

and queueing time, a regression model was estimated relating actual search and queueing time for the surveyed journey to a number of independent variables, including the mode of use of the broadcast service on the day of interview. Table 1 sets out the variables included in the model and summarizes the estimation results.

These results indicate that the two dominant factors influencing drivers' experienced search and queueing time are the time of arrival (acting as a proxy for overall parking demand) and whether park and ride is used. Within this context, however, those who use the broadcast service at the pretrip stage of their journeys enjoy an average reduction of almost 2.5 min in their experienced search and queueing time compared with nonusers of the service, whereas those who delay their use of the service until the en route stage enjoy no significant advantage. The results also show that those who park often in Nottingham enjoy much lower search and queueing times than those who visit less often. The magnitude of the searching and queueing budget also has a statistically significant but numerically small impact.

Structure of Parking Decision Making

Analysis of the responses to the mail-back questionnaires revealed that the vast majority of drivers decided on what type and location of parking they would use before setting out on their journey and that with few exceptions drivers succeeded

TABLE 1 Estimation Results of Regression Analysis of Influences on Parking Search and Queueing Time

Variable	Coefficient (and t-statistic)		
Search and queueing budget	0.079	(7.90)	*
Use of broadcast service on day of interview			
Did not listen	-.-		
Listened first at home	-2.462	(-2.11)	*
Listened first en-route	0.396	(0.56)	
Time of arrival			
08:00-09:00	-.-		
09:00-10:00	-0.609	(-1.20)	
10:00-11:00	1.789	(3.15)	*
11:00-12:00	5.097	(7.67)	*
12:00-13:00	1.106	(1.00)	
13:00-14:00	0.448	(0.69)	
Frequency of parking in Nottingham			
< once per month	-.-		
>= once per month	-1.257	(-3.11)	*
Type of parking chosen			
Park and Ride	-.-		
City Centre	4.039	(10.30)	*
Constant	-0.098	(-0.22)	
Diagnostics			
N	1583		
F	28.21		
df	(1573,10)		
R ²	0.152		

Note: variables marked with an asterisk are significant at the 5% level

in achieving their planned parking. Overall, only 5 percent claimed to set out with no clear idea about where to park, and only 17 percent failed to park where they originally intended. Those intending to park on the street appeared the most susceptible to diversion, with almost 17 percent ultimately using the park and ride and 6 percent parking in a multistory lot.

Although most travelers succeeded in finally parking as they intended, there is considerable variation in the strategies they used to achieve this (Table 2).

Those traveling for work and shopping purposes are least likely to engage in search, with only 11 and 13 percent, respectively, doing other than going directly to a (reasonably) certain space. By comparison, 25 percent of those traveling on personal business and other purposes searched for parking. There is only a small incidence of drivers diverting to park and ride because of parking congestion in the city center, confirming the predominance of the pretrip component of decision making.

Knowledge of Parking in Nottingham

Figure 4 shows the overall distribution of knowledge and experience of parking in the city center. The distribution of drivers' perceived knowledge is highly skewed. Most drivers claim to be aware of several alternative city center parking lots: more than 70 percent claim to know four or more, and just under 20 percent claim to be aware of all nine; fewer than 10 percent admit to knowing none at all. By contrast, actual experience of the use of different parking lots is much more limited, with fewer than 33 percent of all drivers having personal experience of four or more different parking lots. Overall, the median number of parking lots claimed to be known by drivers is six, whereas the median number actually used is three.

Although these findings are by no means inconsistent (since knowledge of parking may be acquired from sources aside from personal experience), the magnitude of the divergence between claimed levels of knowledge and reported experience suggests that at least some drivers may systematically over-

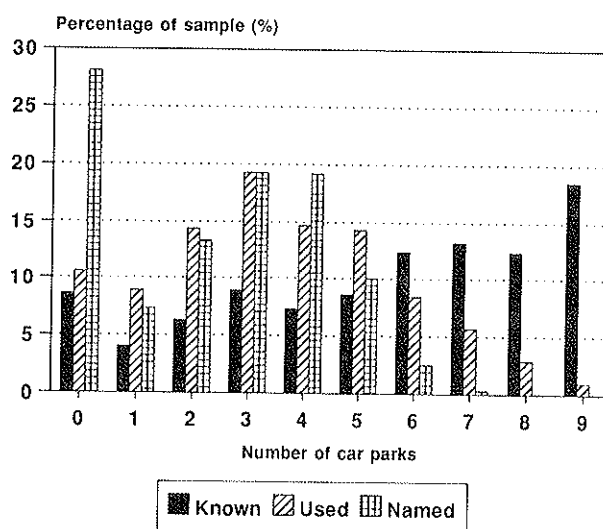


FIGURE 4 Distribution of parking experience and knowledge.

estimate the real level of their effective knowledge of parking opportunities in the city center.

There is even greater divergence between drivers' perceived parking knowledge and their ability to correctly name different parking lots. Name-oriented knowledge shows a strongly bimodal distribution, indicating the existence of two categories of traveler. The first category, consisting of more than 28 percent of the sample, includes those unable to name any of the parking lots correctly, and although this lack of name-oriented knowledge is significantly higher among infrequent visitors ($\chi^2 = 9.9, p < .002$), even among those visiting the city center at least once a week, almost 25 percent do not possess any name-oriented knowledge. (The scoring of the respondents' attempts to name specific parking lots accounted for misspellings and other reasonable variants of the correct name.) Among the rest of the sample, most know the names of three or four parking lots.

There is also considerable variation in drivers' knowledge of different parking lots, with the larger, more popular ones being known, used, and correctly named by a large majority

TABLE 2 Parking Search Strategies

Search Strategy	Journey purpose (%)		
	Work (N=70)	Shop (N=99)	Other (N=146)
"I went directly to a place where I was reasonably certain I would find a space"	76	35	54
"I followed my usual route to my destination which takes me past two or three of my favourite spaces"	6	4	11
"I went directly to my destination and then drove around looking for somewhere to park nearby"	4	4	9
"As soon as I arrived in Nottingham I was on the lookout for an on-street space"	3	0	2
"When I found how difficult parking was in the city centre I went back to the Park and Ride"	0	3	3
"I went directly to the Park and Ride"	11	54	21

of travelers, whereas smaller, less popular facilities are in some cases almost completely unknown by their formal name. Thus, drivers' knowledge and experience of parking in Nottingham is not only partial and in important respects inaccurate, but it is also nonuniformly distributed over the parking stock. It is particularly significant to note that those parking lots that are most well known are precisely those that are most prone to severe congestion and that, conversely, parking lots that are less well known tend to be underused.

Effect on Travel and Parking Behavior

The table that follows shows the proportion of users of the service who have been influenced in different ways by the information provided by the service:

<i>Dimension of Influence</i>	<i>Percentage of Users Affected (N = 216)</i>
Parking location in the city center	45
Use of park and ride	40
Time of day of travel	22
Type of parking in the city center	19
Day of week of travel	9
Mode of travel	8

As might be expected, the broadcast service appears most effective in influencing the choice of parking type and location

within the city center and diversion to park and ride. The former effect may operate either at the pretrip stage or en route; the results of the analysis of parking search behavior just presented suggest that the latter is principally a pretrip effect. Interestingly, there is also evidence that the service has influence on the timing of some journeys, reinforcing the evidence that the service has a significant pretrip impact.

To gain greater insight into the factors that predispose travelers to be influenced by the service, a binary logit choice model was developed that relates whether or not travelers were influenced by the service on the day of survey to a range of personal and journey-related factors. Several specifications of the model were explored, and Table 3 presents the estimation results for two of the most successful formulations developed.

It was decided to concentrate on only the respondents that claimed to be influenced on the day of survey (rather than the larger number that claimed to be influenced generally) so that the specific journey information collected in the survey could be used and the errors of recall and other biases could be reduced.

In both formulations a positive coefficient value indicates the increasing probability of being influenced by the service. Because of the decision to concentrate on only those travelers who were influenced on the day of travel, the estimation data set consisted of only 54 individuals; therefore the results must

TABLE 3 Logit Model of Factors Affecting Influence of Parking Information Service on Traveler Behavior

Variable	Coefficient (and t-statistic)	
	Model 1	Model 2
Gender		
female	-.1	-.1
male	1.055 (1.5)	1.294 (1.7)
Age		
> 45	-.1	-.1
<= 45	1.670 (2.0)	1.451 (1.6)
Journey purpose		
Other	-.1	-.1
Commute	-3.874 (-2.2)	-4.529 (-2.4)
Shopping	-1.176 (-1.2)	-1.490 (-1.4)
Frequency of parking in Nottingham		
>= once per month	-.1	-.1
< once per month	1.422 (1.6)	1.552 (1.6)
Number of car parks known	-0.674 (-2.4)	-0.744 (-2.4)
Number of car parks correctly named	1.318 (2.6)	1.473 (2.6)
Search behaviour		
Searched in Centre	-.1	-.1
Direct to City Centre CP	-.1	1.274 (1.3)
Direct to Park and Ride	-.1	1.674 (1.7)
Constant (No influence)	1.523 (1.2)	2.417 (1.7)
Diagnostics		
N	54	54
Rho-square	0.23	0.28
Rho-square bar	0.20	0.25

be treated with some caution. Despite this caveat several interesting observations emerged.

Both gender and age appear to have a moderate effect on the propensity to be influenced, with males and those under 45 being more likely to change their behavior than females or older age groups. Khattak et al. report similar results in the context of their study of route diversion in response to traffic incident reports (6). Commuters are much less likely to change their behavior than either shoppers or other travelers, possibly reflecting the relatively better overall parking conditions experienced by commuters. Those parking infrequently in Nottingham are also more likely than frequent parkers to be influenced by the service. Those prepared to search for parking within the city center (as opposed to going directly to a parking lot or the park and ride) are less susceptible to influence.

Possibly the most interesting aspect of the modeling results is evidence that they provide for the strong influence of drivers' knowledge of parking on their propensity for being influenced by the service. The results show that the propensity for being influenced by the service decreases with increasing perceived knowledge but increases with increasing levels of name-oriented knowledge. This suggests that travelers who believe that they have a good knowledge of parking in Nottingham may tend to discount the advice of the service, perhaps believing that they know better, but that those who do possess high levels of name-oriented knowledge may be better able to interpret and use the broadcast messages to avoid parking congestion.

SUMMARY AND IMPLICATIONS FOR SYSTEM DESIGN

The survey results have provided a number of important insights into the parking behavior of drivers in Nottingham and the nature of the impact of the broadcast information service.

The results confirm the existence of significant parking congestion in the center of Nottingham that, during periods of peak demand, can add upward of 15 min to normal journey times. Although severe, this congestion is spatially and temporally localized, and over the day as a whole parking conditions in Nottingham are not markedly worse than in many other European cities. Thus, the target audience for the broadcast service is a relatively small and well-defined group, distinguished principally in terms of their intended times of travel and choices of parking. This has provided the opportunity for the specific customization and targeting of the service, in terms of its content, timing, mode of delivery, and promotion.

As a consequence of the careful effort to position the broadcast service with regard to its target audience, there is a high level of awareness of the service, especially among regular radio listeners. It is significant that very few respondents reported that they had difficulties in tuning into the service; this was rarely cited as a reason for not using it. These results imply that in circumstances in which it is possible to identify a specific audience group, local radio can be an effective way to disseminate parking information.

However, although awareness of the service is high, the results of the survey suggest that its impact on parking be-

havior is more limited. In particular, although substantial use is made of the service by drivers en route to the city center, there is little evidence that this mode of use results in any significant impact on parking behavior or experienced search and queueing time. By contrast, the minority of drivers who use the broadcast service at the pretrip stage on average enjoy greatly reduced search and queueing time and are more likely to divert to park and ride.

The explanation for the differential impact of the broadcast service at the pretrip and en route stages is to be found in the structure of drivers' decision-making processes. The survey found that drivers' decisions about the choice of parking type and location are made predominately at the pretrip stage and that with few exceptions drivers succeed in parking in the place that they initially meant to. Once they have embarked on a journey, few drivers appear to be prepared to modify their initial parking intentions, even when informed of severe parking congestion. In particular, most of those arriving during the period of peak parking congestion and intending to use city center multistorey parking lots appear to be prepared to tolerate substantial amounts of searching and queueing in order to achieve their intended parking. There is some evidence that drivers arriving during periods of peak demand become conditioned to expect and therefore are less sensitive to parking congestion. There are, however, significant variations in drivers' tolerance of search and queueing, with those drivers opting to use park and ride displaying a significantly lower tolerance of parking congestion.

Overall, it appears that to have a significant impact on parking behavior, the broadcast service must influence drivers' parking intentions before they set out on their journeys; the service cannot depend on inducing en route diversion. This finding implies that a greater orientation toward the requirements of home-based listeners, in order to encourage more use of the service at the pretrip stage, may well result in a greater impact on parking behavior. Further research would be required to identify these specific requirements.

The survey also demonstrated that drivers' knowledge and experience of parking, particularly with regard to the key aspect of parking lot names, are significant factors in conditioning their use of and response to the service. The results suggest that to be motivated to use the service in the first place, drivers must be willing to concede that the service is in principle able to offer them helpful advice and that, by implication, their own knowledge of parking may be incomplete or inadequate. But the results also show that the impact of the information provided by the service is greater among those with higher levels of name-oriented knowledge, suggesting that the interpretation of the information provided by the service is assisted by greater contextual knowledge of parking. If this is so, then the impact of the service might be enhanced by measures to improve driver familiarity with parking lot names: for example, using clearer signing at parking lots themselves or distributing parking lot maps.

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