Open access • Journal Article • DOI:10.1049/IET-ITS.2012.0167

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Yanjie Ji, Weihong Guo, Phil Blythe, Dounan Tang ...+1 more authors

Institutions: Southeast University, Newcastle University

Published on: 01 Jun 2014 - Iet Intelligent Transport Systems (Newcastle University)

Topics: Parking guidance and information

Ji YJ, Guo W, Blythe PT, Tang D, Wang W.

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***IET Intelligent Transport Systems* 2014, 8(4), 398-406.**

Understanding drivers' perspective on parking guidance information

Yanjie Ji[a], W.Guo[b], P. T.Blythe[b], W.Wang[a]

[a]School of Transportation, Southeast University,China
[b]TransportOperations Research Group,School of Civil Engineering & Geosciences,
Newcastle University, UK

Abstract

Parking guidance and information (PGI) systems are thought to enable a more efficient control and management of the traffic and the use of the available car park in urban areas. Despite the installation of PGI systems in many cities and their operation for a number of years, the levels of usage of PGI remain much lower than expected. To guide investment and operational decisions, this paper examines the existing PGI systems from the drivers' perspective. The results show that PGI is not efficiently used and often ignored by drivers due to the inaccurate or out-of-date nature of the information it is displaying. Habitual behaviour also played an important role in the choices of a car park. However, the results of the research also show that there is a desire for more accurate, dynamic and personalised parking information through different means at pre-trip stage and en-route stage. The results of this survey should provide some guidance in the design of future PGI systems.

Keywords:

Parking guidance, drivers' perspective, parking information

Introduction

It has become the norm in city centres that drivers are forced to drive around longer to search for a parking space. The excessive amount of parking searching time has been identified as a significant contributor to urban congestion and as an important influence in destination choice[1, 2]. Especially when the cost and convenience of parking are not evenly distributed in the city centre. In some cases, small groups of car parks are extremely popular and become full very quickly due to their convenient locations and cheap parking fees, whereas others are underused and only considered as a "last resort" option due to their location and/or high parking charges. It is clear from the literature and from discussions with practitioners that a well designed and efficient parking guidance information can help to improve utilization and management of parking resources[3].

The main objective of most PGI in and around the city centre areas is to reduce the amount of time drivers spend searching for a parking space and to discourage drivers from entering an area if no parking spaces are available – both will consequently have a contribution to reducing the traffic in the city centre. This goal serves to help drivers make informed decisions as well as to help traffic managers' control the urban traffic[4].A research conducted by [5]suggests that such systems can reduce total travel time by up to 40% of for some groups of drivers.

PGI systems are amongst the most common forms of Intelligent Transport Systems (ITS) currently in use in urban traffic management. Advances in information and communication technologies (ICT) and the implementation of effective ITS infrastructure have made it possible for PGI signs to be electronically connected and dynamically updated. To date, PGI signs installed at fixed points in the road network with real time parking information has become the most widely used form of PGI systems[6, 7]. Since the first implementation of the idea in Aachen (West Germany) in the early 1970's,PGIsystems have proliferated in Europe

and beyond. In the mid-1990s, it was estimated that more than 100 PGIsystems had been installed in cities throughout the world with the greatest concentration in the continental Europe, the United Kingdom, and Japan [8, 9].

Despite the large number of PGI systems currently in operation, drivers' usage levels of the systems are much lower than expected. Most of the research on PGI systems has focused ondrivers' awareness and usage of such systemsbut failed to provide a sound understanding of the reasons behind the drivers' reactions to, or usage of PGI system. Andrews and Hillen[10]and Gould and Kinsey [11] suggest that the city-centre based PGI tend to be used most frequently used by visitors rather than regular commuters and local travellers. Those who travel regularly or frequently to an area (e.g. commuters) are less likely to use PGI as they have their local knowledge, favoured parking places, or workplace parking provision and are more likely to follow their habitual choices [12, 13]. Tourists often do not have a specific destination within the city centre in mind and tend to lack knowledge about the parking availability, hence their choices of parking are more likely to be influenced by the PGI systems[14-17]. However,[18] found that the influence of personal characteristics and experiences with PGI system was limited.

Data relating to aggregate parking demand and traffic volume have also been assessed in a number of cities[19]. Reduction in queues and a more even distribution of parking facility use have been reported in some study of PGI systems [20-22]. However, [23] found that, in their network modelling study of the Southampton PGI system, system-wide reductions in travel time and economic benefits were small as often PGI only play a supplementary role in drivers' parking choice processes. [24]used Clemson University campus, in South Carolina,as a case studyto builda traffic simulation model. It was found that use of roadside parking information systems can reduce delay while not significantly affecting volumes, travel times, or speeds. The findings suggestedthe delay reduction was caused by a decrease in vehicle circulation time.

In China, most research about PGI system is focused on the analysis of the layout of parking guidance sign boards. An optimization model for location design of signage boards based on genetic algorithm was formulated and the model break out the usual rule of determining sign boards' locations through qualitative analysis[25]. [26]proposed an optimization model with an objective to maximize the amount of guidance information. [27]set up a location-selecting optimisation modelto specify the positions of variable message signs on road networks.[28]constructed a guiding parking reliability model, with this research tool, the factors that affect guiding reliability were analyzed. Despites those effects and progresses, limited research were conducted focusing on drivers' perspective on PGI system.

Lyons [29] indicates that for ITS to be effective they must be perceived as useful, usable and be used. Therefore investigating the drivers' perceptions of and unsatisfied needs for the existing PGI systems is an important component of the pro-active design of the systems.

This paper presents the results from a specific study of drivers' perceptions of and needs for PGI systems in Newcastle upon Tyne based upon a research collaboration between the Southeast University of China and Newcastle University in the UK. The results from the focus groups and the questionnaire survey will be presented.

Focus groups

Newcastle upon Tyne is a city and metropolitan borough of Tyne and Wear, in North East England.It had a population of 292,200 in 2010 and the urban area is about 112 square

kilometres. Newcastle is the commercial and educational heart of Tyne and Wear and in Partnership with Gateshead supports a diverse economy based upon industry, office-based, service industry and retail employment. As part of Tyneside, Newcastle's economy contributes around £13 billion to the UK GVA. The Central Business District is the centre of the city, bounded by Haymarket, Central Station and the Quayside areas.

Newcastle PGI system has been installed in the city centre of Newcastle and commissioned by the UTMC as part of the urban traffic control functions. It currently includes 59 PGI signs. Overall, 130 car parks are incorporated within the system, servicing approximately 17,000 parking spaces. The system is hierarchical and consists of three types of signs (Fig.1). First type of PGI signs guides drivers to various sub-areas. Within each sub-area, the second type of PGI sign informs drivers to a specific off-street car park using directional arrows to suggest turning points. Close to the entrance of each car park, the third type of PGI sign shows the number of available spaces at the time of arrival and the information about alternative car parks. To all of the PGI signs, the names of the additional area or car park are fixed and the available parking spaces are updated accordingly.

The Newcastle PGI system was designed to improve the accessibility of the city centre for drivers and to help re-distribute excess demand from popular car parks and reduce on-street parking. However, it has not been as effective as expected. For example, Eldon Square multi storey car park whose capacity is 492 and John Dobson Street multi storey car park whose capacity is 540 are the two largest off-street car parks in Newcastle city centre. The distance between the two car parks is about 0.4 mile.In the peak time, usually all the spaces are occupied in Eldon Square multi storey car park and less than half spaces are occupiedin John Dobson Street multi storey car park. It indicates that the occupancy rates of various car parks in the city centre remained uneven.The expected effect of the system has not been achieved.Therefore, it is important to investigate the problems associated with the existing PGI system and what improvements are needed from the drivers' perspective.

Type 1 Type 2 Type 3

Figure 1 Examples of PGI signs (Newcastle)

To gather views on Newcastle PGI system from a large group of drivers in a standardised way, a questionnaire survey was selected. To research the usage and issues with the current PGI provision in Newcastle a series of data gathering excises were undertaken: initially some pilot focus groups were held to investigate the key issues and then a larger data collection exercise through a survey were executed which would explore the issues raised in more detail and with a larger cohort of responses. In early December 2011, two focus groups were held in Newcastle University to pilot the questionnaire designed for this study. The focus groups include 7 male drivers and 4 female drivers. They were held with 5 members in group one and

6 members in group two. In the case of PGI, these focus groups had five main questions to discuss:

1) How often do you use the PGI and where?
2) Why do/do not you use them?
3) Where would you need the parking information?
4) What parking information would you like to have at different decision points?
5) What format of the parking guidance information do you prefer at different decision points?

Both focus groups considered that PGI usually did not work efficiently and they did not rely on them in a familiar area. In general the opinions of the groups were that the number of the available parking spaces had neither been timely updated nor accurate. They also stated that it was generally difficult to find an available parking space on weekends in the city centre of Newcastle, especially in the free or cheaper car parks.

Participants expressed a desire for real-time parking information using an in-vehicle device and PGI signs were identified as the second favourable way to receive more detailed parking information. Most of them would plan their unfamiliar or long distance journeys and look for car parks near their destinations on the internet before they travel.

Most of the participants pointed out that getting parking information at junctions or roundabouts is more important as getting the location of available parking spacein the car park. They also agreed that PGI signs should not be ambiguous, should use consistent user interfaces and should be easy to understand. Too much information would confuse them and distract their attention from driving. In an unfamiliar city, names of car parks usually donot make sense to drivers if they do not know the location of that car park.The design of the PGI signs should consider the characteristics of parking facilities, land use patterns and function present in the cities.

Questionnaire survey

Following the focus groups, the questionnaire was modified accordingly to explore in more detail the key issues raised by the focus groups. To address these points, the questionnaire was developed to collect obtain views and opinions on the choices. Firstly, different means for receiving real-time parking information was developed for drivers to choose in the questionnaire due to participants of focus groups expressed the desire for receiving information from in-vehicle devices. Secondly, the question about the parking information demand at pre-trip stage and en-route stage were added in the modified questionnaire because drivers usually have different parking information demands at the two stages. Thirdly, a question about drivers' typical annual mileage was added for know more about drivers' general driving habits.

After the modifications and another round of piloting, the questionnaire was distributed to drivers through the internet and physically handed out at a number of car parks in Newcastle. Drivers were asked questions relating to their use of PGI system and their desire for parking guidance information. Numerous personal and driving habits were also collected.

A total of 215questionnaires were completed over the two weeks (from 15th March to 1st April 2012), 120 males and 95 females. The age of respondents were fairly evenly divided over the range of 20-70 years (Fig.2).

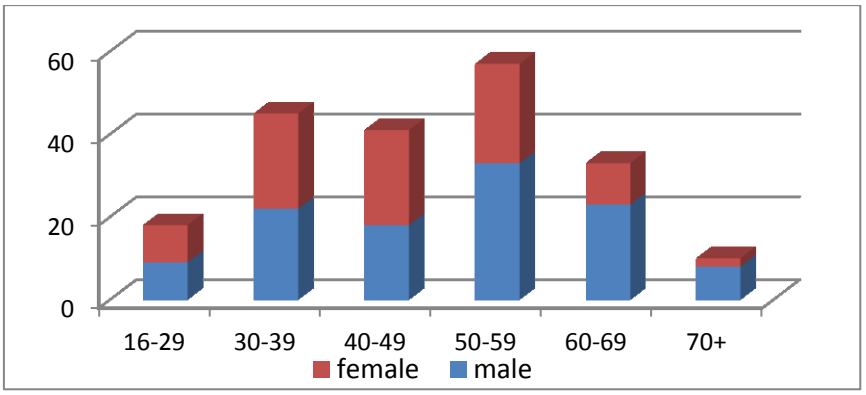

Figure 2 Respondents' Age and Gender

General driving habits

The driving habits information collected for drivers in the survey include drive frequency, annual mileage and usage of car parks (Table 1). Among the total 215 respondents, 55.7% said that they drive very often, however 68.3% of drivers' typical annual mileage is less than 10,000 miles which implies many of the journeys undertaken were of a short distance. Most drivers (52%) used to choose off-street car parks 1-7 days per week, while 55% of drivers use on-street car parks 1-3 days or less than once per month.

Table 1 Drivers' general driving habits

Question	Response	% of sample	
How often do you drive?	Occasionally (less than once a month)	5.4	
	Sometimes (1-3 days a month)	10.3	
	Often (1-3 days a week)	28.6	
	Very often (most days a week)	55.7	
What is your typical annual mileage?	0-5,000 miles	36.1	
	5,000-10,000 miles	32.2	
	10,000-15,000 miles	23.8	
	More than 15,000 miles	7.9	
		Off-street	On-street
How often do you use off-street and on-street car parks?	Never	3.48	4.15
	Less than once per month	18.41	27.46
	1-3 days per month	26.37	27.46
	1-3 days per week	21.39	19.69
	4-7 days per week	30.35	21.24

Parking difficulty

Five trip destinations were surveyed in the study: city centre, business places, residential area, supermarket and others. To all respondents, the city centre is the most difficult location to park and, in general, a supermarket is regarded as the easiest location for drivers to park (see Table 2). On average, female drivers generally found it more difficult to find an available parking space than male drivers. This finding could indicate that more parking guidance information of city centre should be provided to drivers and especially female drivers, however the questionnaire was not really focused on understanding if there were clear differences in the information requirements of male and female drivers – this work is now

ongoing. A few drivers also mentioned that university, school and hospital were difficult to find available parking spaces.

Table 2 Mean value of parking difficulty based on locations of trip destination

Gender			City centre	Business places	Residential area	supermarket
male	N	valid	118	116	119	115
		missing	2	4	1	5
	Mean value		2.21	2.75	3.27	4.36
female	N	valid	94	88	94	93
		missing	1	7	1	2
	Mean value		2.07	2.63	3.03	3.94

(Parking difficulty was assessed by a 5-point Likert scale: 1-very difficult, 2-quite difficult, 3-ok, 4-quite easy,5-very easy)

Use PGI signs

A number of statistical analysis techniques were used to investigate relationship between driver and trip characteristics and PGI system awareness, understanding and usage. The chi-squared test and logistic regression were used to determine the significance of any relationships [30].

The chi-squared test was used to investigate the independence of driver awareness, understanding and usage of the PGI system with individual trip and personal characteristics[31, 32]. This test compares two-way frequency count(contingency table) data with expected frequencies-estimated assuming independence. Thisanalysis was used to determine if relationships existed between two variables.

Binomial Logistic regression modelwas developed for relating the likelihood of drivers' use of the PGI system to various personal characteristics and driving habits. The model was used to identify significant personal and driving habits parameters influencing the probability of drivers' using the PGI signs. This technique allowed the relative influence of a number of Boolean variables on driver response to be estimated.

Overall, 53% of drivers interviewed ever used the PGI signs to find available parking spaces. Of those who have used the PGI signs, 35% had actively used the signs within the last month, 35% had actively used the signs in the past 1-3 months and 30% had reported using the signs within the past 3 months. All the respondents who reported using the signs had travelled into the city centre on a number of occasions however they only tended to use the PGI signs when the traffic was very busy (so they were less confident that their preferred parking location would be available) or the respondents were unfamiliar to the city centre area and tended to rely on the PGI for their infrequent sojourns into the city. This clearly indicates that there are two distinct customers for PGI signs.

The chi-squared test revealed that drivers using PGI signs had correlations to drivers' gender, drive frequency and annual mileage. Moreover, the responses suggested that driver's age has no significant relationship with driver's use of PGI signs (see Table 3). Logistic regression also revealed that female and annual mileage had positive effects on the likelihood of drivers using the signs. The responses also indicated that there was a negative relationship between drive frequencies and usage of the signs (see Table 4). As stated previously the survey also suggested that female drivers were slightly more likely to use the PGI signs than males. In addition the survey showed that drivers with annual mileages more than 15,000 miles were

more likely to use PGI signs to find available parking spaces and also that long distance journeys increase as annual mileage increase. An obvious conclusion of this is that drivers with significant numbers of long distance journeys have more chances to drive in citieswhere they are unfamiliar with the layout of car parks, and hence drivers with high annual mileageswill more likely to use PGI signs to find available parking spaces. This result is similar to the studies observed in the Frankfurt, Leeds, and Shinjuku[8, 30, 33] The results also confirmed that commuters often tended to ignore the signs and rely more on their own knowledge gained from experience (except when the uncertainty of heavy traffic conditions, such as a large scale vent or Christmas shopping make using their favoured parking locations problematic) and tourists with minimal knowledge of the parking system are more likely to have their choice of car park influenced by PGI signs. The logistic model also showed that drivers with lower drive frequency were more likely to use PGI signs. Commuters with high drive frequency, who have a good network and parking system knowledge, do not perceive the need for the information presented on PGI signs. The ability of PGI systems to inform these types of drivers seems limited.

Table 3 Chi-square analysis results for using PGI signs

	Age	Gender	Drive frequency	Annual mileage
Using PGI signs	n.s.[a]	*[b]	*	**[c]

[a] Not significant;[b]Significant at 10%; [c]Significant at 5%.

Table 4 Preferred logistic regression model for using PGI signs

Variables		Coefficient	Standard error
Female		0.348	0.097
Drive frequency	1-3 days a month	-0.253	0.026
	1-3 days a week	-0.377	0.064
	most days a week	-0.870	0.051
Annual mileage	5,000-10,000 miles	0.498	0.078
	10,000-15,000 miles	0.899	0.032
	more than 15,000 miles	1.337	0.031

Locations forusing PGI signs

The questionnaire survey asked respondents who have used PGI signs to indicate the location where they last used the signs and also for respondents who haven't used the signs to indicate, in their opinion their preferred the locations for PGI signs. Overall, of those drivers have used PGI signs, 48.5% chose the location close to the entrance of the car park. Of those drivers who haven't used PGI signs, 45.6% chosethe location at junctions or roundabouts where one of the roads/exits will take them to the car parks (see Table 5). This suggests that many drivers noticed PGI signs near car parks and didn't notice the PGI signs at junctions although they did indicate that they wished to get parking information at junctions. More attention should be directed towards informing drivers of the presence of PGI signs at junctions or roundabouts. A general view from the questionnaire was that more acceptable format of PGI signs located in more prominent position would increase the likelihood of drivers noticing them.

Table 5 Locations using PGI signs chose by drivers

Locations	Have used PGI signs	Haven't used PGI signs
On major roads (motorways or dual carriageways)	16.8%	18.4%
At junctions of roundabouts	34.7%	45.6%
Close to the entrance of the car park	48.5%	36%

Parking information needs of drivers

The survey also investigated drivers' preferences for different type of parking information at the pre-trip and en-route stage. It is considered important to undertake a market analysis of drivers' desire for various types of parking information where the current PGI system is not well utilised.

At the pre-trip stage, the most requested type of parking information related to the parking fees at alternative parking locations (see Table 6). However, a substantial proportion of drivers indicated their preference for information relating to a map which indicates the names and locations of car parks in the destination area, opening and closing time, information about alternative car parks when the chosen car park is full and number of available spaces of different car parks. This clearly is a difficult set of information to provide on a standard PGI due to its complexity and detail. Related to this, a few drivers requested step by step directions to each car park and parking reservation at this stage.

At the en-route stage, most drivers preferred to receiving parking information in a form of some sort of map that indicates the names and locations of car parks and navigation to car parks from in-vehicle devices (e.g. Satellite navigation system). With PGI sign boards, most drivers preferred information about number of available spaces of different car parks, information about alternative car parks when the chosen car park is full, parking fee and opening and closing time (see Table 7).

Table 6 Parking information types requested by drivers at pre-trip stage

Type of information	% all respondents
A map indicates the names and locations of car parks	73.5
Step by step directions to each car park	28.4
Number of available spaces of different car parks	58.8
Parking fee	79.4
Opening and closing time	73.0
Information about alternative car parks when the chosen car park is full	60.8
Parking reservation	21.6

Table 7 Parking information types requested by drivers at en-route stage

Type of information	In-vehicle devices (% all respondents)	Sign boards (% all respondents)
A map indicates names and locations of car parks	51.0	28.9
Navigation to car parks	52.5	38.2
Number of available spaces of different car parks	14.7	73.0
Names of car park	26.0	39.2

Parking fee	18.6	59.3
Opening and closing time	20.1	55.9
Information about alternative car parks when the chosen car park is full	17.6	62.7

The Chi-square test was used to identify any statistically significant relationships between driver factors and their preference for the most requested types of parking information at the pre-trip and en-route stage (see Table 8 to 10). A separate technique was used to identify any substantially under or over represented classes within the factors that were found to be related at a statistically significant level.

Table 8 Chi-square analysis for parking information types at pre-trip stage

Factor	Map	Availability	Fee	Time	Alternativecar parks
age	n.s.[a]	n.s.	n.s.	n.s.	n.s.
gender	*[b]	n.s.	**	n.s.	*
Drive frequency	n.s.	*	n.s.	*	n.s.
Annual mileage	**[c]	**	***[d]	*	n.s.

[a] Not significant; [b] Significant at 10%; [c]Significant at 5%; [d] Significant at 1%.

Table 9 Chi-square analysis for en-route information received from in-vehicle devices

Factor	Map	Navigation	Name	Time
age	n.s.[a]	*	*	n.s.
gender	n.s.	n.s.	n.s.	n.s.
Drive frequency	n.s.	**[c]	n.s.	*
Annual mileage	*[b]	n.s.	n.s.	n.s.
Used PGI signs	***[d]	***	**	n.s.

[a] Not significant; [b] Significant at 10%; [c]Significant at 5%; [d] Significant at 1%.

Table 10 Chi-square analysis for en-route information received from PGI signs

Factor	Availability	Fee	Time	Alternative car parks
age	n.s.[a]	n.s.	n.s.	n.s.
gender	n.s.	n.s.	*	***[d]
Drive frequency	n.s.	*	**	**
Annual mileage	*[b]	**[c]	n.s.	n.s.
Used PGI signs	*	n.s.	n.s.	**

[a] Not significant; [b] Significant at 10%; [c]Significant at 5%; [d] Significant at 1%.

1) A map indicates the names and locations of car parks in the destination area

At the pre-trip stage, a majority of all the drivers interviewed requested map-based information relating to the names and locations of car parks at pre-trip stage (73.5%). The chi-square test results indicated significant relationships between drivers' desire for map information and their annual mileage and whether or not they used the PGI signs.Male drivers whose annual mileage is from10,000 to 15,000 miles were well over-represented in requesting map information. Female drivers whose annual mileage is from 0 to 5,000 miles were under represented. This suggests that male drivers with long distance journeys like to know about parking facilities near the destination and female drivers with short journeys usually do not care about parking before trips.

At the en-route stage, 51% of drivers desire to receive map information from in-vehicle devices. This was found to be related to annual mileage and whether or not have used PGI signs. Those have used PGI signs and annual mileage from10,000 to 15,000 miles were well over-represented. Drivers with a propensity to undertake longer distance journeys have lower perceived level of parking system knowledge near the destination area and are more likely to receive map information from in-vehicle devices.

2) Navigation to car parks

At pre-trip stage, few drivers (28.4%) desire to step by step directions to each car park. While at en-route stage, 52.5% want to receive navigation information from in-vehicle devices. The chi-square test results indicated significant relationship between drivers' desire for map information and their age, drive frequency and whether or not they used the PGI signs. High drive frequency drivers whose ages are under 39 and have used PGI signs would like to receive navigation to car park information from in-vehicle devices. So high drive frequency and younger drivers need real time navigation information received from in-vehicle devices when they are en-route.

3) Number of available spaces of different car parks

At the pre-trip stage, approximately 60% of respondents indicated their desire for the availability of car parks information. It was found that drive frequency and annual mileage related to this information. Drivers whose annual mileage is from10,000 to 15,000 miles and who reported driving most days a week were well over-represented in requesting availability information.

At the en-route stage, 73% respondents desire to receive availability information from PGI signs. Drivers whose annual mileage is from10,000 to 15,000 miles and have used PGI signs reported that they pay more attention to the information about number of available spaces of different car parks.While drivers whose annual mileageswereless than 5,000 miles and haven't used PGI signs were significantly under represented.It also appears that drivers often with short distance journeys don't want to receive availability information due to their familiarity with the car parks status.

4) Parking fee

At the pre-trip stage, 80% drivers want to receive information about parking fee. It was found that gender and annual mileage were related to this type of information. Female drivers whose annual mileages were between 10,000 to 15,000 miles were over-represented in receiving the information. It suggests that female drivers usually with long distance journeys indicated a strong preference to get detailed parking information before their trips.

At the en-route stage, about 60% respondents indicated their desire to receive parking fee information from PGI signs. A significant relationship was found between drivers' annual mileage and the desire to have parking fee information. Drive frequency was also found to be related to this information. Drivers with high drive frequency and high annual mileage were over-represented in receiving parking fee information. This suggests that drivers usually with long distance journeys require wider range of parking information from PGI signs.

5) Opening and closing time

At the pre-trip stage, 73% of all drivers requested information relating to car parks opening and closing time. There was a significant relationship between age and this information. Drive frequency and annual mileage were also found to be related. Very frequent drivers whose annual mileages were above 10,000 mileages were well over-represented. Drivers usually with longer distance journeys want to know about car parks opening and closing time before trips.

At the en-route stage, a high percentage of drivers (55.9%) desired this type of information received from PGI signs. Gender and drive frequency were found to be related to this information. Female drivers with lower drive frequency were over-represented in receiving time information. Obviously, they need get detailed parking information from PGI signs when they are en-route.

6) Information about alternative car parks when the chosen car park is full

Approximately 61% of respondents requested information about alternative car parks when the chosen car park is full at pre-trip stage. Gender was found to be related to this type of information. More female drivers indicated that they wished for such information before their trips.

At the en-route stage, 63% drivers indicated a desire to receive this type of information from PGI signs. There was a significant relationship between gender and information about alternative car parks. Drive frequency and whether have used GPI signs were also strongly correlated to this information. Female drivers with lower drive frequency and have used PGI signs were well over-represented. These female drivers need more informed decisions regarding their parking choice due to limited knowledge and experience in car parks.

7) Names of car park

Information about names of car park is not very important to most of drivers. About 39% drivers desire to receive this type of information from PGI signs, moreover 26% drivers want to receive this information from in-vehicle devices. Age and whether they have used PGI signs were related to names of car park received form PGI signs. Older drivers whose age are above 60 and have used PGI signs are more likely to get this type of information from PGI signs which conforms other studies on information requirements for older drivers .However, names of car parks usually do not make sense to most drivers in an unfamiliar city.

8) Parking reservation

Parking reservation is developed for drivers at pre-trip stage and it can help drivers to find a vacant parking space even before beginning their trip. But only 21.6% respondents are interested in this type of information.

9) Other information

Some drivers desire for information about the security rating of the parking facility (do cars often get broken into, is the car-park manned at all times, etc.), method of payment and height restrictions of car parks.

Channels for receiving en-route parking information

The survey also asked respondents how favourable drivers are with different means of receiving parking information at en-route stage. Four channels were surveyed in the study: local radio, smart phone, in-vehicle device and PGI sign. About 32.3% of drivers don't want to receive parking information from local radio (see Table 11). It shows that local radio is not favourable for most of respondents. However, PGI sign is the most favourable means although it is not in efficient use now. In-vehicle devices and smart phone are also popular mechanisms to provide en-route information. It is considered important to use multi guidance means in the delivery of PGI. While PGI signs are the favourite means to receive parking information when en-route, further analysis of favourable PGI sign format should be undertook for the efficient use of the signs.

Table 11 Mean value of different channels for receiving parking information

		Local radio	Smart phone	In-vehicle devices	PGI signs
N	valid	200	201	201	205
	missing	15	14	14	10
No (% all respondents)		32.3%	28.4%	9.8%	2.0%
Mean value of favourable		2.66	3.08	3.69	4.15

(Means favourable was assessed by a 5-point Likert scale: 1-least favourable, 2-lessfavourable, 3- ok, 4-quite favourable, 5-mostfavourable)

Format of PGI signs

Although PGI signs have been installed in many cities around the world, there is little published knowledge as to drivers' reaction to different PGI sign formats. This survey addressed this by presented a number of different generic formats of PGI signs to show to the survey respondents at three different locations to gauge opinions (the options are illustrated in Figure 3). Some of the signs shown are familiar ones, used in many locations, others have been specifically designed for this study to test the respondents opinions on the future possibilities for PGI signs. When presented with the signing options at the three locations where these signs could be located: upon entering the city centre, most drivers desire to receive information from sign types B and A; at junctions in the city centre, about 41% are interested in sign type B and 25% chose sign type G; and at the entrance of a car park, a majority of drivers (71%) want to see sign type H (see Table 12).

A

B

C

D

E

F

G

H

Figure 3 Different formats of PGI signs

Table 12 Format of PGI signs preferred by drivers (% all respondents)

Locations	A	B	C	D	E	F	G	H
Upon entering the city centre	24.5	**51.5**	2.0	3.9	1.5	6.9	7.8	0
At junctions in the city centre	0.5	**40.7**	3.9	7.4	10.3	10.8	24.5	0
At the entrance of a car park	0.5	3.4	1.5	1.0	3.9	2.5	9.8	**71.1**

Sign type B was very popular to most drivers when they were upon entering the city centre and at junctions in the city centre.A very simple road map on sign type B is easier for drivers to catch the information about parking locations while the multiple lines of words on sign type A usually make drivers confused. However, although sign type E has the same simple road map, few drivers preferred to sign type E due to the means of expression about available parking spaces. Sign type B indicates the expected number of available spaces of car parks while sign type E uses words such as 'SPACES' and 'FULL'. Obviously, drivers like to know about the exact number of available parking spaces (they commented that they like to know that there are a number of spaces available before choosing a car park as then hope that with the margin of error of cars entering or leaving a car park before they arrive at it, there is a strong chance that there will still be a space available for them). Sign type H is preferred by most of drivers to receive information at the entrance of a car park. It can show drivers available parking spaces of different levels at a parking garage. By extension, available parking spaces of sub-areas can also be shown on the PGI signs at the entrance of a park lots with large area.

The above result showed that clear and easy to understand are more important in the design of format of PGI signs. Upon entering the city centre, signs type B can be used to show the expect number of available parking spaces in different area of city centre. At junctions in the city centre, sign B can also be preferred to show the number of available parking spaces of different car parks near the junctions. At the entrance of a park garage, sign type H is very suitable to show the available spaces of different levels. And if it is a park lots with large area, sign H can be changed to show the available spaces of different sub-areas.

Conclusions

The paper presents the results from a questionnaire surveyconducted in Newcastle upon Tyne with the aimof investigating the effectiveness of the city's PGI system from the drivers' perspective. The findings indicate that driverswho have a good knowledge about the road networks and parking system including those commuting to Newcastle by cardo not perceive the need for PGI highly. Although many drivers expressed the desire to get parking information at junctions, they admitted that they generally only noticed PGI signs near the entrance of car parks, not so often at those at junctions. This may imply that the PGS signs need to be more prominent at junctions so to be seen by drivers easily, however additional driver workload at the junction may also be a factor in the respondents not noticing or using the information on the PGI signs.

At the pre-trip stage, gender differences became evident regarding the need for information on parking. Female drivers showed a higherdemand for PGI than their male counterpart. Male drivers, particularly those who often drove for long distance journeys,showed a lower level of need for information on the name and location of the car parks, number of available spaces, parking fees, opening and closing time and alternative car parks if the chosen one was full.

At en-route stage, younger drivers with high drive frequency indicated a clear need for real time navigation to car parks from in-vehicles devices while drivers with high annual mileage presented a stronger desire for information on name and location of car parks. Such information was expected to be displayed onan in-vehicle device or a smart phone rather than the roadside PGI signsfor navigation purpose. Other information such as the number of available spaces of different car parks was expected to be shown onthe roadside PGI signs.Again, female drivers demanded a wider range of parking informationfrom PGI signs,such as alternative car parks when the chosen car park is full, parking fee and opening and closing time. In general, being able to access PGI through multiple means is considered important.

For the efficiency of PGI signs, further investigation of the format of PGI signs was undertaken. In total, eight formats were shown in the questionnaire. Sign Bindicating the expected number of available spaces of car parks on a simple road mapand is preferred to be used for PGI signs installed at the entrance of the city centre and main junctions in the city centreby most drivers. Sign H showing available parking spaces of different levels at a parking garage is generally recognised as suitable for PGI signs locate at the entrance of a car park.

In conclusion,for PGIsystems to achieve the goal of reducing the amount of time drivers spend searching for a parking space and traffic in the city centre, they need to be delivered through the proper means withaccurate, up-to-date, relevant information showing in the right format. Intelligent transport systems in concert with UTMC systems have the capability to monitor, sense and collect information on both traffic conditions and parking space availability – in many cases this needs to be used more effectively with PGI systems so information displayed is correct (and hence trusted), timely and understandable. Moreover the use of pre-trip planning systems and in-vehicle information systems, either a bespoke satellite navigation system, or some 'app' on a smart phone clearly offer new channels for personalised PGI delivery. Further research will explore parking guidance strategy when multi guidance means are used in the delivery of PGI which is being undertaken by Southeast University in China and research specifically on information and ITS for older drivers is being undertaken by Newcastle University in the UK.

Acknowledgement

The financial support from the National Key Basic Research Program of China (No. 2012CB725402) and the National Natural Science Foundation of China (No.50908051) is gratefully acknowledged. The authors would also like to thank for the support from the Transport Operations Research Group, in the School of Civil Engineering and Geosciences at Newcastle University and the support of UKRC Digital Hub, SiDE project.

References:

1. Donald C, S., *Cruising for parking.* Transport Policy, 2006. **13**(6): p. 479-486.
2. Gallo, M., L. D'Acierno, and B. Montella, *A multilayer model to simulate cruising for parking in urban areas.* Transport Policy, 2011. **18**(5): p. 735-744.
3. Caicedo, F., *Real-time parking information management to reduce search time, vehicle displacement and emissions.* Transportation Research Part D, 2010. **15**: p. 228-234.
4. Jonkers, E., M. van Noort, and J. van der Veen, *Parking guidance - modelling, simulation and impact assessment*, in *IEEE International Conference on Intelligent Transportation Systems-ITSC*. 2011. p. 858-864.
5. Asakura, Y. and M. Kashiwadani, *Evaluation of availability information service by parking choice simulation*, in *Proceedings International Conference on Advanced Technologies in Transportation and Traffic Management*. 1994: Centre for Transportation Studies, Nanyang Technological University,Singapore.
6. Teodorović, D. and P. Lučić, *Intelligent parking systems.* European Journal of Operational Research, 2006. **175**(3): p. 1666-1681.
7. Song, J. and W. ZK, *Study on Urban parking guidance information system design*, in *Fourth international conference on machine vision (ICMV): computer vision and image analysis: pattern recognition and basic technologies*. 2011: Singapore.
8. Axhausen, K.W. and J.W. Polak, *A disaggregate model of the effects of parking guidance systems*, in *7th WCTR Proceedings*. 1995: Sydney, Australia.
9. Rodier, C.J. and S.A. Shaheen, *Transit-based smart parking: An evaluation of the San Francisco bay area field test.* Transportation Research Part C, 2010. **18**: p. 225-233.
10. Andrews, D. and S.M. Hillen, *Compact UTC Car Par Information System*, in *the PTRC Summer Annual Meeting* 1980: Warwick.
11. Gould, P. and P.J. Kinsey, *Variable direction signs to car parks- Truro experiment*, D.o.T. Traffic Advisory Unit, Editor. 1981: London.
12. Shaheen, S.A., *Smart Parking Management Field Test: A Bay Area Rapid Transit (BART) District Parking Demonstration*. 2005, Institute of Transportation Studies, UC Davis.
13. Anderson, C.M., C. Das, and T.J. Tyrrell, *Parking preferences among tourists in Newport, Rhode Island.* Transportation Research Part A 2006. **40**: p. 334-353.
14. Hilton, I.C., G.A. Swindley, and P. Thurlwell, *Parking search traffic in central Manchester*, UMIST, Editor. 1989: Manchester.
15. Axhausen, K.W., M.B.J.W. Polak, and J.Puzicha, *Effectiveness of the parking guidance information system in Frankfurt am Main.* Traffic engineering and control, 1994.
16. Thompson, R.G. and P. Bonsall, *Drivers' response to parking guidance and information systems.* Transport Reviews, 1997. **17**(2): p. 89-104.
17. Thompson, R.G., K. Takada, and S. Kobayakawa, *Understanding the demand for access information.* Transportation Research Part C: Emerging Technologies, 1998. **6**(4): p. 231-245.
18. van der Waerden, P., H. Timmermans, and P. Barzeele, *Car Drivers' Preferences Regarding Location and Contents of Parking Guidance Systems Stated Choice Approach.* Transportation research record, 2011. **2245**: p. 63-69.
19. C.O.Tong, S.C.Wong, and B.S.Y.Leung, *Estimation of parking accumulation profiles from survey data.* Transportation Research Part A, 2004. **31**: p. 183-202.

20. Suzuki, T. and S. Yamomoto, *Parking system for highways in cities*, in *Proceeding of Intelligent Transportation Systems World Congress*. 1997: Berlin.
21. Kurauchi, F., et al., *Dynamic traffic simulation model for evaluating parking guidance and information system*, H.K.S.f.T. Studies, Editor. 1998: Hong Kong.
22. Thompson, R.G., K. Takada, and S. Kobayakawa, *Optimisation of parking guidance and information systems display configurations.* Transportation Research Part C: Emerging Technologies, 2001. **9**(1): p. 69-85.
23. Waterson, B.J., N.B. Hounsell, and K. Chatterjee, *Quantifying the potential savings in travel time resulting from parking guidance systems - a simulation case study.* Journal of the Operational Research Society, 2001. **52**(10): p. 1067-1077.
24. Fries, R., et al., *Evaluation of Real-Time Parking Information Case Study of Isolated University Campus.* Transportation research record, 2010. **2189**: p. 1-7.
25. ke-fei, Y., et al., *Location of sign boards in a parking guidance information system (PGIS) based on genetic algorithm.* China Civil Engineering Journal, 2006. **39**(7): p. 104-108.
26. Zhang Bao-yu, Y. Ke-fei, and Z. Xiang-ting, *Optimization of PGI signs location determination on the base of parking guidance behavior survey.* Systems Engineering, 2007. **25**(3): p. 87-93.
27. Qun, C. and S. Feng, *Locating of variable message signs in parking guidance systems* Proceedings of the institution of civil engineers-transport 2010. **163**(3): p. 111-118.
28. Mei, Z., T. Y, and D. Li, *Analysis of Parking Reliability Guidance of Urban Parking Variable Message Sign System,.* Mathematical problems in engineering, 2012.
29. Lyons, G., *Transport Direct Market Research Programme: Findings and Implications from Phase 1*, in *Transport Direct, Department for Transport*. 2003.
30. Thompson, R.G. and K. Takada, *Driver Reactions to Parking Guidance and Information Systems: Some Japanese Experiences*, in *Proceedings International Conference on Intelligent Transport Systems*. 1995: Australia.
31. Mendenhall, W. and R.L. Scheaffer, *Mathematical Statistics with Applications*. 1973, North Scituate,mass: Ducbury Press.
32. Greenwood, P.E. and M.S. Nikulin, *A Guide to Chi-Squared Testing* ed. 1. 1996: Wiley-Interscience.
33. Smith, J. and S. Phillips, *Evaluation of the Leeds car park guidance system*. 1992, Transport Research Laboratory: Crowthorne, U.K.