Connected Places Catapult

Autonomous Valet Parking

CATAPULT
Connected Places

Contents

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1. Introduction

1.1 The Autonomous Valet Parking Project

The Innovate UK funded Autonomous Valet Parking (AVP) project runs between 2018-2020, with the key aim of identifying obstacles to full deployment of AVP through the development of a technology demonstrator. The consortium consists of Parkopedia (the lead partner), University of Surrey and the Connected Places Catapult (CPC).

The CPC's role in the project is to understand the impact of AVP on the parking industry, as well as to develop safety cases to support the testing of the AVP demonstrator. This report summarises the customer and user research carried out to understand social and behavioural barriers to, and impact of, AVP.

Innovate UK
Centre for Connected & Autonomous Vehicles

Parkopedia

UNIVERSITY OF SURREY

1.2 Customer and User Research

The Customer and User Research was carried out between June 2018 and January 2019 with the aim of exploring:

- Customer and user **needs** for the AVP Solution
- Customer and user **attitudes** to AVP
- The **impact** of AVP, specifically on the environment, economy and society

Research questions guiding the study were:

- What are the key parking pain points that can be resolved by AVP?
- What are other likely benefits of AVP to users and parking stakeholders?
- What are the key barriers to AVP deployment and uptake, from a social and behavioural point of view?
- What will be the likely impact of AVP, on the environment, the economy, and the parking industry?

To better understand the impacts, benefits, and barriers of AVP a mixed-methods approach was used. Customers and users considered in the research were: 1) Drivers, as they will be the end-users of AVP, 2) Parking professionals, as deployment of AVP will rely on buy-in from the car parking industry, and 3) Automotive manufacturers, or OEMs, as they are key stakeholders in the adoption of AVP.

The methodological approaches used were:

- A **literature review** to explore existing knowledge about the chosen research topics and questions
- **Stakeholder interviews** with parking professionals and OEMs to explore their views of AVP
- **Focus group interviews** to explore the needs and attitudes of drivers in-depth

- A UK wide **survey** to complement the focus group interview data. The survey data was used to examine differences between user groups, and to gauge how common certain attitudes or needs are

In addition to these approaches, **ethnographic field research** at places where valet parking is currently offered as a service was planned. The purpose of this approach was to observe first-hand how valet parking is being carried out, and to explore the views of valet parking staff and users in-situ. However – despite repeated attempts at gaining approval from service operators – access to a valet parking site to carry out the research was not acquired. While this is unfortunate, user perspectives of valet parking were explored as part of the focus groups and in the survey. It is likely that the field research would have complemented and confirmed those findings rather than generating significantly new or different ones.

1.3 Report Outline

The remaining report includes:

- Detailed accounts of the four different research elements, each including a summary of the approach, a presentation of results, and a summary of key findings
- Overall conclusions and a list of recommendations

2. Literature Review

The literature review was the first study to be carried out as part of the customer and user research. The aim was to map existing research on the current state of UK parking, user needs and attitudes relating to autonomous valet parking (AVP), as well as on the expected impact of AVP. The review also sought to identify research gaps.

The review encompassed academic papers as well as grey literature. Sources included social science research (including economics), market and social research carried out in the public domain, and relevant literature on the topics of the environment and technology. Literature examining the following topics were of particular interest:

- Parking experience, such as:
    - What is the current level of parking supply and demand?
    - What are the existing parking barriers and pain-points?
- Impact of parking on the economy, environment, and society
- Legislation and autonomous valet parking
- Autonomous valet parking challenge areas
    - Public attitudes to, and trust in, autonomous parking and valet parking
    - Innovative parking solutions (including automated solutions)

The review excluded literature that:

- Was not specific to the UK situation. However, multinational comparative studies were included, provided that an examination of the UK situation formed part of the comparison
- Was published before 2015 (for literature on autonomy)
- Was published before 2010 (for all other topics)

To gather relevant literature, search terms were initially broad, and then refined and narrowed iteratively throughout the collection process. Collected literature was first scanned and evaluated based on its relevance to the aim of the review. Then, selected literature was reviewed, and key findings summarised.

The searches for literature on user and customer experience of parking generated fewer results than expected. Typically much market research is not made available in the public domain, at the same time as academic research would usually not concern itself with the research questions examined in this study.

2.1 The UK Parking Situation

2.1.1 Market overview

In 2013, the British Parking Association (BPA) estimated that there are 17,000 parking facilities in the UK[1]. Of those, 48% are run by local authorities and most are surface facilities. 20% of multi-storey and underground facilities are over 40 years old. The same research estimates that there are between 8 and 11.3 million parking spaces in the UK, and 12% to 18% of those are for disabled drivers/passengers. The occupancy rate is lower for local authority (50-80% occupancy) than privately owned parking (80% occupancy). Approximately 82,000 people work in parking, out of which most are low-skilled (BPA 2013).

London is the 7th most expensive city globally for parking, according to the 2017 Global Parking Index. By contrast, the UK comes in at the 16th most expensive overall (Parkopedia 2017).

2.1.2 Purpose of use and user characteristics

Research by the RAC Foundation (2012) found that, outside of London, 70% of people commute by car, and workplace parking dominates the time cars are parked elsewhere than home. Most people travelling to work park their cars in company car parks. Other reasons for parking, such as shopping, social, and recreational, account for 27% of weekday parking (RAC Foundation 2012)[2].

Public car parks are primarily used by shoppers and those travelling for social and recreational activities. For destination parking, nearly 70% of all parking acts are for less than 3 hours, and nearly 90% are for less than 8.5 hours. Aside from holiday parking, workplace parking has the greatest duration (RAC Foundation, 2012)[3].

The characteristics of the average car park user is likely to vary depending on where the car park is situated. In a comparison between city car park users and park and ride users in Bath, Clayton and colleagues (2014) found that the former group was more likely to start/end their journey in higher income bracket areas than the latter. The study also found that most car park users were between 35-59yo and that they usually accessed the park for shopping and personal business[4].

Research by Opinium[5] on behalf of the British Parking Association found that 17% of drivers have used a parking app or gone online to find somewhere to park.

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[1] The results of the study are based on engagement with 198 stakeholders in the UK parking sector, carried out by Skyblue Research in October 2011.
[2] These figures result from an analysis of National Travel Survey (NTS) data from 2002-2006.
[3] Based on an analysis of NTS data 2002-2006.
[4] The data was collected through an on-board survey of park and ride users (721 respondents), an on-street survey of car park users (564 respondents) and face-to-face surveys (number of respondents not disclosed).
[5] Based on a survey of 2000 nationally representative UK adults (aged 18 and over)

2.1.3 Pain points

Drivers experience a lot of pain and frustration parking their cars. The Traveller Needs and UK capability study (2015) revealed 12 challenges to Intelligent Mobility of which 'solving the parking challenge' was one[6]. This challenge is linked to others, such as 'enable faster journeys and increased confidence in arrival time.' According to the survey, travellers struggled to find parking on 12% of car journeys (or 4.3bn journeys), rising to 14% if considering only urban journeys, and 19% of journeys in London[7].

A survey by the RAC Foundation (2012) found that 31% of car drivers and passengers did not experience a problem with parking availability. However, 38% said availability was an issue when visiting a hospital, 30% had problems when shopping, and 21% when doing personal trips. In a 2010 study[8] of rail passengers parking their cars near train stations, Passenger Focus found that the car park factors passengers were least satisfied with were: value for money (10%), payment machines (17%), and traffic flow around the car park (39%) (Passenger focus 2011). A study by ParkMark (2013) also observed that car park users felt pay machine problems were a great annoyance[9].

Research by Passenger Focus (2011) found that satisfaction with getting a space was relatively high amongst commuters (74%). By contrast, leisure passengers often found themselves competing for spaces, and therefore satisfaction with finding a space dropped off considerably in this passenger group, to just 58%. Respondents' top priorities for improvement were: 1) cheaper day and season ticket prices (28% and 21%), 2) more efficient pay machines (10%), 3) more spaces for cars (8%), and 4) larger parking spaces (7%) (Passenger Focus 2011).

In Opinium's (2016) survey study, 44% of respondents reported that they think finding somewhere to park is stressful. The most frustrating aspects of parking reported were 1) it being too expensive (64%), other people taking up more than one space (59%), and insufficient number of parking spaces (48%).

2.1.4 Drivers of use

According to BPA (2013), the primary drivers of parking demand is the extent of vehicle ownership and journey destination. Other factors include:

- demographics
- economic activity
- transport options
- land use patterns
- prices and demand management strategies
- commercial development
- popularity and price of alternative transportation
- cost of parking

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[6] Figures based on a UK wide survey with 10,000 respondents.
[7] Since there are now several companies that - based on real-time and predicted availability - allow drivers to search, reserve, and pay for off-street parking in advance, it is possible that this may have reduced the number of journeys where finding a space is an issue since the 2015 study. However, further research would be needed to confirm this assumption.
[8] Figures based on data from the National Passenger Survey 2011. The NPS surveys 25,000 rail passengers bi-annually.
[9] Based on a face-to-face survey with 642 car park users.

- changes in work practices (e.g. flexible work hours and home working)

Car parking is also affected by fuel prices – every 1% increase in fuel prices reduces vehicle travel by 0.75% for middle income rural residents and by 0.93% for low income urban households (BPA 2013). However, RAC Foundation (2012) found that around 50% of drivers did not think the cost of petrol and parking affected their parking behaviour at all.

The Traveller Needs study (2015) notes that avoiding unexpected delays and having confidence in arrival time is more important to travellers than the journey time itself. Travellers will value a seamless journey experience with parking solutions that increase arrival time confidence, such as space reservation and integrated payment. The study also found that drivers would be willing to pay £0.42 per journey to be able to reserve a parking space and be guided to it. Two thirds of this value come from being able to guarantee the space and one third from the routing element. The incremental value of this across the 4.3bn journeys where parking causes pain in the UK is £1.8bn.

Drivers' perceptions and experiences of parking facilities at different destinations can also influence where they end up going. National Car Parks' (NCP) study of the importance of parking for shoppers (where 2000 people were surveyed) found that, when deciding to go to a shopping centre or retail park, drivers would consider factors such as car park safety, cost, risk of incurring a Parking Charge Notice (PCN), time spent finding a parking space, and amount of available parking spaces (National Car Parks, year unknown).

In a related vein, ParkMark (2013) found that choice of car park is influenced by ease of access and safety, and that there was a preference for car parks that were closer to the destination, and where parking was easy (for example with spaces wide enough to comfortably fit a car). However, the study also found that the respondents' choices were less influenced by parking cost – two out of three respondents said closeness to destination was more important than cost, and only 16% would choose the cheapest option. This is echoed by Bergantino and colleagues (2015), who note that in-vehicle time has a smaller impact on the choice of parking location than out-vehicle time does. For example, the time it takes to walk from the parking space to the final destination (egress time) plays a bigger role in the decision of where to park, than does the time spent searching and queuing for a parking space (search time) (Bergantino et al. 2015).

Opinium's (2016) research found that 26% of respondents would rather park in a car park than on the street. 28% would opt for the parking location they perceived as safest, 21% would pick the lowest-cost parking option, and 16% would choose parking location based on proximity to end-destination. The factors that respondents felt were particularly important to consider when deciding where to park were cost (70%), location (67%) and the ease of access (51%).

NCP's research also found that two of the three most important factors for consumers visiting a shopping centre or a retail park were parking related – 72% felt low cost parking was essential, and 55% said it was important that the parking facilities were of a high standard. 50% of shoppers avoided certain shopping centres or retail parks out of concern they would have parking issues there (NCP, year unknown). In addition, if the parking experience at a particular shopping centre had been poor, 55% of respondents stated that they would not return. By contrast, 70% said they were more loyal to shopping centres where parking was easy and 75% would be more likely to visit a shopping centre if a parking space was guaranteed (NCP, year unknown).

With regards to payment, 50% of respondents to Opinium's survey (2016) preferred pay and display systems, using cash. Out of all those who reported a preference for pay and display (both those who

preferred paying by cash and card), 48% said this was because it is quicker and easier than using online, mobile, or text methods while 37% felt it gave them better control of what they pay. Of respondents who preferred paying by cash, 39% said this was because they do not trust electronic payment methods (Opinium 2016).

When it comes to desired parking improvements, NCP found that the most desirable features of car parks were signs that direct drivers to free spaces, or that let them know about free spaces (NCP, year unknown).

2.2 Impact of Parking

Brooke and colleagues (2017) argue that the negative environmental and economic impact of parking search is due to a combination of increased 1) network traffic flow and congestion, 2) noise emissions and air pollution, 3) time delays for individuals who are slowed down by vehicles searching for parking, and 4) safety hazards caused by vehicles manoeuvring in and out of parking spaces. The authors note that parking search constitutes 14% of traffic density and causes a 50% increase in congestion-related time-loss. On average, the time spent searching for parking increases the estimated commuting time by 20% (Brooke et al. 2017). Shoup (2011) estimates that in times of heavy traffic congestion, up to 30% of that traffic consists of vehicles looking for parking spaces[10] and ParkMark (2013) estimates that it takes on average 10-15 minutes for drivers to find parking. This suggests that parking search has a considerable effect on emissions and air pollution, although this will also include impact caused by drivers searching for on-street parking.

To add to this problem, some councils appear to have an inadequate understanding of on-street parking demand and where the problem of parking search is most critical. In an interview study of how local authorities perceive on-street parking search, Brooke and colleagues (2017) found that council officers generally believe that the largest volumes of vehicles searching for parking happen in peripheral urban areas or attractive market towns. This despite there being a lack of evidence of on-street parking search volumes, which makes it difficult to assess where it happens and the extent of it.

Drawing on previous research on parking, Inci (2015) analyses the economic issues associated with parking.[11] He notes that a disproportionate amount of existing research focuses on the economic impact of cars being in motion, even though cars are parked for up to 95% of the time and take up a significant amount of land mass while parked[12]. RAC Foundation (2012) estimates that the average car spends about 80% of its time parked at home, and is parked elsewhere for about 16% of the time. This means that the average UK car is only in actual use for 3-4% of the time.

Inci argues that, because most car transportation activities begin and end with parking, parking is one of the most important “intermediate good” in modern society (2015:50). He examines three main economic issues associated with parking (specifically as related to price and quantity of parking).

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[10] This is based on an examination of 16 studies conducted around the world between 1927 and 2001

[11] In particular, the aspects analysed in Inci’s review are 1) cruising for parking, 2) spatial competition, 3) parking requirements, and 4) parking and road pricing.

[12] Inci notes that, in Europe, the total land taken up by parking is approximately equivalent to one-half the land area of Belgium (2015:50).

- Cruising for parking, or parking search. This is commonly a result of a mismatch between on-street parking supply and demand, and "imposes external costs on all drivers by increasing congestion" (Inci 2015:51)
- Spatial competition in the parking sector, especially as linked to car park owners/operators' exercise of market power. Inci notes that regulations specifying how much parking must be supplied in each zone of a city are often adopted ad hoc, while car parks are "often discretely spaced throughout a city" (Inci 2015:51) In combination, this distorts parking supply and land use
- The relationship between underpricing and congestion, which is especially relevant for certain types of parking (e.g. workplace parking, shopping mall parking, residential parking)

The RAC Foundation (2012) found that UK households spend on average £47 on destination parking fees per year, however their research did not cover the average cost of residential parking. For English councils, revenues from parking is a significant source of income. RAC Foundation (2017) notes that English councils made £819 million from their parking operations in 2016, or 10% more than in 2015. The total income was £1.582 billion, out of which £763 million were reinvested into running parking operations. Insufficient or inadequate parking may however have a knock-on effect on local economies, as it can be a problem for businesses trying to attract customers (see e.g. Yorkshire Forward).

2.3 Autonomous Valet Parking

2.3.1 Future impact

A vision of fully autonomous vehicles (AVs) able to park outside of city centres in suburbs or city outskirts is likely to save substantial amounts on parking costs (Fagnant and Kockelman 2015). Whilst not every AV will result in a relocated or removed parking space, Fagnant and Kockelman estimates that every AV will save $250 on parking per annum (based on an assumption of 10% of AVs being publicly shared). However, if parking is priced but road use is not, then AVs may simply cruise around instead of parking, increasing congestion (Litman 2018), although it seems likely that regulation would be introduced to prevent this (citation required). Also, user demands of AV parking may require the vehicle to be returned within five to ten minutes of being 'called,' precluding the option in many cities to relocate parking spaces to the edge of the city.

Compared to regular car parks that have only two rows of vehicles in each island, future car parks (for autonomous vehicles only) can have multiple rows of vehicles stacked behind each other. It has been estimated that AV car parks can decrease need for parking space by an average of 62% and a maximum of 87% (Nourinejad et al. 2018). The exact design and strategy for retrieving AVs, such as maximum time to deliver, will be determined by the service models developed.

A reduced need for parking spaces based on the assumption that people will share vehicles more than they do currently is difficult to predict, and further evidence on future trends toward ride sharing (e.g. based on current car usage patterns) is required. However, if able to allocate specific areas to AVP, car park operators can increase patronage of the car park provided that enough vehicles are fitted with the technology capability, and drivers are willing to use the technology.

2.3.2 Legislative issues

On the 6th of March 2018, the government began a three-year review of its driving laws, to identify and examine legal obstacles to the roll-out of autonomous vehicles and suggest appropriate regulatory reforms (Gov.uk 2018). A key focus will be adapting existing laws to autonomous vehicles, which will not be controlled by human drivers and may even be lacking a steering wheel. The work is part of the Future

of Mobility Grand Challenge, which falls under UK's Industrial Strategy. Specifically, the review focuses on 1) who the driver or responsible person is in autonomous driving scenarios, 2) how to allocate civil and criminal responsibility, 3) the role of AVs in public transport networks, on-demand passenger and car-sharing services, and other new MaaS business models, 4) new potential criminal offences, and 5) the impact on other users and how to protect them.

In 2018, the Transport Systems Catapult reviewed the UK's legal framework and its implications for AV testing. The table below summarises the regulations of particular relevance to autonomous valet parking[13].

REGULATION	FRAMEWORK
Regulation 104: "No person shall drive or cause or permit any other person to drive, a motor vehicle on a road if he is in such a position that he cannot have proper control of the vehicle or have a full view of the road and traffic ahead."	Road Vehicles (Construction and Use) Regulations 1986; under section 41 Road Traffic Act 1988
Regulation 107: "(2), no person shall leave, or cause or permit to be left, on a road a motor vehicle which is not attended by a person licensed to drive it unless the engine is stopped and any parking brake with which the vehicle is required to be equipped is effectively set."	Road Vehicles (Construction and Use) Regulations 1986; under section 41 Road Traffic Act 1988
Regulation 109: "(1) No person shall drive, or cause or permit to be driven, a motor vehicle on a road, if the driver is in such a position as to be able to see, whether directly or by reflection, a television receiving apparatus or other cinematographic apparatus used to display anything other than information: (a) about the state of the vehicle or its equipment; (b) about the location of the vehicle and the road on which it is located; (c) to assist the driver to see the road adjacent to the vehicle; or (d) to assist the driver to reach his destination."	Road Vehicles (Construction and Use) Regulations 1986; under section 41 Road Traffic Act 1988
Regulation 110: "No person shall drive a motor vehicle on a road if he is using: (a) a hand-held mobile telephone; or (b) a hand-held device of a kind specified in paragraph (4)"	Road Vehicles (Construction and Use) Regulations 1986; under section 41 Road Traffic Act 1988

[13] On the question of what counts as a road in the Highway Code and the Road Traffic Act, Annex 4 of the Highway Code states that "[m]ost of the provisions apply on all roads throughout Great Britain, although there are some exceptions. The definition of a road in England and Wales is 'any highway and any other road to which the public has access and includes bridges over which a road passes' (RTA 1988 sect 192(1)). […] It is important to note that references to 'road' therefore generally include footpaths, bridleways and cycle tracks, and many roadways and driveways on private land **(including many car parks)." (**https://www.gov.uk/guidance/the-highway-code/annex-4-the-road-user-and-the-law, emphasis added)

Section 170: "Duty of driver to stop, report accident and give information or documents. […] (2) The driver of the [mechanically propelled vehicle] must stop and, if required to do so by any person having reasonable grounds for so requiring, give his name and address and also the name and address of the owner and the identification marks of the vehicle. (3) If for any reason the driver of the [mechanically propelled vehicle] does not give his name and address under subsection (2) above, he must report the accident. (4) A person who fails to comply with subsection (2) or (3) above is guilty of an offence."	Road Traffic Act 1988
Rule 160: "Once moving you should: drive with both hands on the wheel where possible. This will help you to remain in full control of the vehicle at all times."	The Highway Code

FIGURE 2.1: Regulations of relevance to AVP

For autonomous valet parking, laws around remote control parking are of particular relevance. Remote control parking allows the driver to exit their vehicle and use a mobile device to command the vehicle in and out of a parking space. If the driver is not within a certain range to the vehicle, the system will not function. At present, the legal limit within which the driver is allowed to operate their vehicle is six metres. In addition, during the parking manoeuvre, the driver will be required to continuously activate the remote-control device, else the vehicle will come to a stop. The Centre for Connected and Autonomous Vehicles (CCAV) notes that these "will be useful in informing the public of the safe use parameters in line with international rules," "ameliorate any concern over the proximity of the operator of the remote-control device in relation to the car," and "serve to reassure the public that this kind of system will not be abused" (CCAV 2017:11; see also CCAV 2018).

While these amendments are not yet ideal for autonomous valet parking, CCAV (2017:11) note that future iterations "will likely take into account future remote-control systems such as valet parking, where it is expected that the vehicle could be out of the driver's sight while the parking manoeuvre is completed".

2.3.3 Public attitudes

There is little evidence around the impact of AVP in UK beyond the Gateway Project (see below). Autonomous vehicle parking is discussed more widely in papers that describe future possible scenarios, and generally focused on fully autonomous vehicles that can drive anywhere on the road network. Therefore, learnings from evidence on public attitudes towards autonomous vehicles more generally will be applied to AVP and, in particular, a SAE Level 4 solution where the cars will operate in a controlled environment.

The Gateway Project (undertaken in Greenwich, London) conducted a small-scale trial of autonomous valet parking where the trial participants drove to a hotel, left the car, entered a viewing point in the hotel, and triggered the car parking itself via an app. The car then parked in the concourse area immediately outside the hotel. Gathering feedback from the 35 participants, the potential benefits identified are: save/manage time, improved safety, improved inclusivity, and stress reduction. Reflecting on the interaction with the application, the design of the service needs to provide users with a sense of control and the option of personalisation. It was observed that, whilst some people trust technology and

think that the autonomous vehicle is ‘better than people’, others need to be completely reassured that it is safe and reliable, and would therefore need evidence of exhaustive testing to adopt the service.

It will be important to understand what types of information and control different types of user will need when using an AVP function in a car. The benefits of saving time coupled with removing people from potentially stressful situations can be a powerful motivation for drivers to want to use AVP. The types of user, such as likely early adopters or those distrustful of new technology, will potentially have a bearing over the outcome of an AVP demonstrator.

Daziano and colleagues (2017) consulted a consumer panel (in USA) about demand and willingness to pay for full automation of their private car. The study estimated substantial heterogeneity in preferences for automation with demand modelled as evenly split between high, modest and no demand. Chan (2017:212) comments that "many surveys have shown that consumers are not necessarily ready to pay for the automation features, and in some cases, there is outright rejection of the notion of owning an automated vehicle.” The potential problem of autonomous vehicles not being socially accepted is evident, although research suggests that many people are already open to the concept and will be advocates for it, whilst others completely reject the idea.

Abraham and colleagues (2016) note that the trust to adopt AV technologies is not yet here and may need to be built-up over time. The older population may be particularly hesitant, even though they are a group who could greatly benefit from it. However, more than half of the older adult market “appears comfortable with the concept of technological innovations that help the driver” (Abraham et al. 2016:11).

The 2017 UK Autodrive public attitudes survey reports that whilst the general levels of awareness of autonomous vehicles are relatively high (76%), hard-line attitudes are yet to set in due to the technology being in its infancy. People in the UK are open-minded about AVs and very few are strongly against it at this stage. However, the pervading attitude is that AVs are for ‘everyone else except me.’ This, as the report comments, is a response which suggests an element of uncertainty, or lack of trust, in the new technology.

Trust in AV technology varies, but as the SAE Level 4 or 5 autonomous car is not yet on the roads of UK and in few controlled scenarios (e.g. Heathrow shuttle), it is difficult to judge public opinion. For each survey or study, it is not clear whether respondents have the same conception of a driverless car before providing their attitudes towards it. It will be vital when consulting with the public during this project to explain that it is Level 4 technology (and how that is different to Level 5) operating within a controlled environment.

The VENTURER project in West of England aims to establish safe user-led trialling of connected and autonomous vehicle (CAV) technology. Their trial of “Interactions Between Autonomous Vehicles and Other Vehicles on Links and at Junctions” suggested that, in order encourage public trust in AVs, the vehicles will need to operate with more caution than the average driver. Overall, participants showed greater trust in situations when the autonomous vehicle was driving in the more cautious setting, such as always giving way. That the vehicle demonstrates less assertiveness than the average human driver may also be a significant factor in public acceptance of AVP, even when operating off the roads in a confined and defined car park.

A further VENTURER trial dealing with “Interactions Between Autonomous Vehicles and Pedestrians and Cyclists” found that trust of the AVs was more sensitive to movement and noise of the vehicle rather than the perceived risk. The authors conclude that during the early stages of AV development, it is

important to understand that smoothness of manoeuvres has an impact on the public's perception of safety and trust. Most people (drivers as well as non-drivers) are highly familiar with moving vehicles. Therefore, acceptance of AVs will be higher if they operate in similar ways cars currently do, albeit the fact that human drivers' behaviour varies must also be taken into consideration.

From the two VENTURER trials we can conclude that pedestrians and cyclists will accept AVs if they 'behave' in a familiar manner, whilst other car drivers desire AVs to drive conservatively. The car manoeuvring to a car parking space in AVP mode should drive in a predictable and safe manner. Within a car park, dependent on the layout and location designated for AVP, the AVP cars may avoid 'crossing paths' with human driven cars and pedestrians. However, trials of the technology may want to demonstrate an ability to operate alongside other car park users.

2.3.4 Current parking innovations

There are two AVP solutions being trialled in Germany. Bosch and Daimler have developed technology using sensors and IT (built into the physical infrastructure) that communicates with the vehicle to locate and drive to an available parking space. The Volkswagen Group report developing a similar approach at Hamburg Airport using pictorial markers located in the car park and that the vehicle sensors use for localisation. For roll out of these, the sensors and technology would need to be fitted within every car park.

In the United States, and at London Gatwick Airport, there are several examples of robots being used to transport cars to parking spaces. These solutions save time and are designed to be easy for drivers, at the same time as the car itself does not have to be particularly sophisticated. At the PearlWest office and entertainment development in Boulder (US), Park Plus technology means cars are transported via robotic dollies, which transfer them to small compartment spaces in the garage's storage vault. The planned Willoughby Square project in Brooklyn (US) has made automated parking a cornerstone of its development plan. Drivers will pull their cars into entry rooms and sensors and cameras record the car's dimensions before it is lowered into a tightly designed parking vault. A series of automated hoists will return cars from the bay and return it to the driver. It will be interesting to compare operational efficiency and user experience of the two approaches to automated parking, i.e. between autonomous valet parking solutions and solutions relying on robots transporting the car.

Many smartphone applications are now available to assist with parking. These tend to show location of parking spaces, prices and directions to the car park. Some apps also provide direct booking and payment for parking. When apps are able to direct the driver to a specific reserved space this will be an alternative to AVP as it will remove the 'pain' of searching for a space. Some parking platform businesses offer parking sensors which could be used to achieve this.

Smart Parking Ltd offers barrier free car parking, with 'ticketless' payment assumedly made via an account. They also describe overhead guidance signage within car parks. These again are innovations that can make the parking experience better.

Luxe, in USA, created an app that allows a valet (human) to come to where you are to park the car and then returns it to your stated location later – a traditional service booked and paid for digitally. Vallie[14] offered a similar on-demand parking service in London through their app. A post-mortem published on their website suggests that the business is no longer in operation due to a loss-leading business model[15].

2.5 Summary of Literature Review Findings

The literature review has covered research on 1) the current parking situation in the UK, 2) The impact of parking on the environment and economy, 3) Impact, barriers, and attitudes towards autonomous valet parking, and 4) current parking innovations.

Key takeaways from the literature review are that:

- Parking is one of the biggest pain points experienced by drivers, and certain parking related pains could be alleviated by autonomous valet parking
- Satisfactory evidence on the impact of AVP is lacking
- Further research on users' attitudes towards AVP is needed to ascertain what is required for adoption of the technology

The diagram below summarises user requirements from the car parking experience and how an AVP solution could meet these.

Want	Features	AVP solution
Easy	Close to destination	Saves time
	Easy to pay (cashless, account)	Need to integrate payment
	Available spaces	No need to search
	Clear navigation to spaces	No need to navigate
Safe	Security	Need to reassure
	Lighting	No need to enter car park
	Design (wide spaces, easy to drive)	No need to park/ navigate
Cheap	Low cost	Need to offer value
	Flexible pricing	Need to offer value

reduced stress, appointments kept, predictable journeys

Loyalty, repeat visits, advocacy

FIGURE 2.2: Overview of user requirements that can be addressed by AVP

In addition, the following implications for AVP were noted:

- Clarification is required with regards to whether a car with AVP capability can legally drive without a driver within a car park and whether a car park operator would be able to reject a vehicle with AVP capability from exercising it in the car park
- Saving time parking will benefit commuters and shoppers, so an AVP solution could benefit employers and retailers as well as the car drivers

[14] http://www.vallie.co.uk/

[15] https://blog.vallie.co.uk/vallie-a-post-mortem-on-on-demand-parking-in-london-a56933a27ddc

- Reducing congestion caused by parking searches will be headline benefit but would be maximised if the AVP solution is combined with pre-bookable spaces and integrated into journey planning
- Current research into public attitudes towards AVs focuses on a future with fully autonomous vehicles. It will be important in this project to understand people's views on AVP as an autonomous function within the controlled environment of a car park
- Current AV research shows users of an AVP service would want personalisation and a sense of control. Other drivers and pedestrians would want the AVP car to drive conservatively and be predictable (human-like). It may be that initial demonstrations could avoid AVP cars 'crossing paths' with human driven cars and pedestrians – however this may not be the way to engender trust in the technology
- It will be interesting to monitor the progress of the Bosch/Daimler and VW trials of AVP in Germany and it is important to monitor for further examples (in UK and Europe) of the 'robot moving cars' solutions to parking
- New parking apps that aim to improve the parking experience and make it easier to find, reserve and pay for parking are frequently introduced to the market. Consideration of these successes should be built into the service design for AVP

3. Stakeholder Interviews

This section summarises the findings of the stakeholder interviews carried out in August and October 2018 to explore stakeholders' views on:

- Legislative implications and liability
- Different types of autonomous valet parking solutions
- Physical layout of car parks and AVP zones
- Benefits and implications of AVP
- Barriers for AVP

To explore these topics, the views of automotive OEMs and parking professionals were sought.

In total, two local authority representatives, three car park professionals, and one OEM were interviewed. Recruitment activities generated fewer participants than estimated, and it was particularly difficult to engage with OEMs. Potential stakeholders were identified through the project team's lists of contacts and from stakeholder contacts. Efforts to recruit additional participants continued up until December 2018.

Interviews were semi-structured, lasted approximately 30-45 minutes, and were exclusively carried out over the phone. A topic guide was prepared prior to the interviews, but flexibility was allowed for respondents to expand on topics aligning with their expertise and interest.

3.1 Legislative Implications

Several stakeholders mentioned that car parks are in many cases located on private land, meaning public law might not apply formally there. One of the local authority professionals believed that the relatively controlled area of the car park would make AVP easier to implement from a legislative perspective, and that there would be far fewer regulatory and social barriers in such a controlled environment.

Another local authority stakeholder expressed the need for issuing a license or agreement for a service like this to operate under, as legal certainty around potential issues is required.

These views should be considered in light of the law commission's ongoing review of the regulatory framework for safe deployment of autonomous vehicles in the UK (see section 2.3.1 of this report), which at the time of these interviews was under consultation (and closed on 8th February 2019).

3.2 Liability

Not surprisingly, stakeholders felt that liability for an accident or incident inside the car park would depend on the underlying cause of the incident.

> *"The owner is probably not liable, at least not if it is the technology that isn't working. I suppose it depends on what have gone wrong, such as if the car park hasn't been mapped correctly. We wouldn't want it to be the council, although an injured person would probably look to the council first!"*
>
> *Local authority stakeholder*

One stakeholder mentioned that liability is closely linked to insurance, and perhaps in particular the supplier's or service provider's insurance. Most car park operators in the UK do not hold sufficient insurance for customers' vehicles to cover valet parking, and in effect AVP, incidents:

"In the UK, parking operators have insurance that doesn't give them any way to insure vehicles while they are in the car park - the responsibility of the vehicle typically lies with the driver and not the operator. Operators would be reluctant to accept liability for a service like AVP, while in the US operators provide valet services under their insurances.

Airport parking and places where traditional valet parking is carried out are exceptions; they will have special insurance. But for traditional car parking this is something operators have not really considered – they'd worry about extra cost of insurance, staff, and whether people will pay the premium charge (of valet)."

Car parking professional

The same stakeholder suggested that liability should remain with the supplier or manufacturer, given they are producing the know-how and delivering the technology. Doing so would also help remove barriers to entry:

"[This would] make it easier to sell AVP and for customers to adopt the technology. Relying on operators to change their ways and take more responsibility would be a very strong barrier to entry. The manufacturer must reassure operators and users that what they are developing is going to work, and that they will take responsibility if the technology fails."

Car parking professional

On the topic of insurance, the car park professional also suggested that it will be very hard for drivers to accept AVP if an incident outside of their control will affect their excess. There was general agreement that this is an area of insurance policy that needs more work and that policies around AVP will have to be clear and well-defined.

The main issue, it was felt, is whether there will be enough evidence to ascertain what went wrong during an accident or incident. As for the responsibility to notify relevant bodies in the case of an incident, several stakeholders mentioned the option of having a third party respond to and handle incidents.

3.3 Infrastructure-heavy vs Infrastructure-light AVP Solutions

Most of the parking professionals expressed preference for an infrastructure-light AVP solution (i.e. one that requires minimal changes to the car park in which the AVP system would be operated). Infrastructure-light solutions may also make operators more willing to offer the service, as they wouldn't themselves have to invest as much in their car parks. If the AVP solution is predominantly reliant on the car park being "smart", i.e. infrastructure-heavy, one stakeholder argued that it would make AVP much less flexible. That is because it was felt to make it much harder to park vehicles closer together (and increase car park capacity), because "the sensors [installed in the car park] itself do not know the size of the object parked on top of it." (Car parking professional) However, as an infrastructure-heavy solution would effectively tele-operate vehicles, it might be better able to coordinate the effort of moving multiple vehicles around and optimising their proximity to each other when parked compared to a solution that relies entirely on autonomous vehicles coordinating the parking routine with each other.

The OEM stakeholder favoured an infrastructure-heavy AVP solution. They acknowledged that infrastructure can be costly, but considered this to be "the main way to get over the barrier of safety. The other advantage is that the vehicle is cheaper to customers."

3.3.1 Service design and business models

There was much talk about how the AVP experience could be designed to meet customers' needs, and what the business model would look like. Most interviewees tended to agree that AVP is a service, and a trade association stakeholder expressed that – as a service – it will have to be seamless and easy to use to attract customers. The car parking professional agreed with the emphasis on ensuring a good customer experience, as – in the parking industry – it is "far easier to keep a customer, than to gain one."

The OEM stakeholder noted that it will be easier for customers to adopt the technology if they are not owning the car (but using it as part of a service), and felt the best way to drive adoption would be to target fleet operators. Similarly, a local authority stakeholder expressed that, if AVP will be expensive and unaffordable for most private users, the business model will likely be more centred around shared fleets than individual ownership.

Whether or not AVP will be offered as a premium service will affect who the target customer is. If it comes at an extra cost, adopters will primarily be "business people looking to save time." At the same time, a premium service will be difficult to sell to the general public "as they are looking for ways of paying the least amount possible" (Car parking professional).

Payment systems were also discussed at some length. A local authority stakeholder mentioned that pay and display car parks would not be well suited for AVP. Rather, AVP would benefit from being linked to some payment system (like RingGo), so that both driver and car park owner know that the parking is paid for. This would also have the benefit of easing the driver pain of paying for parking.

Another stakeholder argued that payment should be account based – i.e. with automatic billing based on time spent in car park – to ease the driver's worry about payment. This would also be of benefit to car park operators, who would then know they will get paid "every single time" (Trade association stakeholder).

3.4 Physical Layout of AVP car park

When asked about zones for drop off and pick up, a stakeholder from a local authority suggested that this will depend on how the car park is used and how predictable customers' movements are. For instance, airport car parks will require a different layout from a business car park. However, it was also noted that there is only so much one can do to change the layout of car parks – the shape and structure of them are typically difficult to alter.

Another stakeholder suggested that the drop off/pick up area would resemble that of traditional valet parking, where customers leave their cars in a designated area close to the entrance. However, a trade association stakeholder noted that this would require quite a bit of changes to regular car parks, which – unlike e.g. airport car parks – do not already have drop-off zones and are not made for this type of service.

> *"[Where drop-off and pick-up would happen] depends on the physical constraints of the car park and what they have in way of space at the entry. Some may have a spare lane and others may have a foyer behind the barriers. Moving the barriers could also be an option."*
>
> *Trade association stakeholder*

One of the parking professionals mentioned that an important question to ask with regards to the placement of zones is when does the contract between driver and car park operator start.

"At the moment, the contract starts either when the customer takes a ticket or when they enter and park at the facility. So, the location of zones will depend on how the contract is initiated – in an analogous way (e.g. car entry) or in a digital way (e.g. through a smart phone). It is something that needs to be firmed up, because you might have a vehicle that is able to park itself, but lack a smart device to initiate the contract."

Car parking professional

As for where the vehicles will park – in a closed off area or amongst regular cars – stakeholders had differing views. A common sentiment was that it would vary from car park to car park, depending on factors such as demand, layout, and capacity.

"It would be determined case by case – operators would assess whether it is worthwhile giving up some space for AVP or if it is better to let them park anywhere."

Trade association stakeholder

Several stakeholders mentioned that for AVP to be attractive to car park operators, the vehicles should first look to occupy spaces that other drivers are keen to avoid such as those located at the top of the car park or in hard-to park areas (e.g. in-between pillars). It was not believed that customers would care if their AVP vehicle parked somewhere where it was exposed to the weather, as long as they are aware that that is a possibility.

There was some mention of future-proofing for electric and autonomous vehicles by installing electric chargers at AVP parking spaces. For AVP, this would have to involve induction charging or other solutions not requiring human involvement. Once fully charged, the vehicle could then move to another empty spot to leave room for other EVs to charge.

It was emphasised that the proportion of spaces allocated to AVP vehicles at any one time should remain flexible to allow for changes in demand.

"The number of spaces allowed for AVP may change over time as the software becomes more widespread. Any contracts between car park operators and manufacturers would have to include agreements around how the level of service and capacity changes as demand changes."

Trade association stakeholder

3.5 Barriers

3.5.1 Operators

Several parking professionals mentioned that it will be difficult to convince car park operators to make AVP available in their car parks. One of the reasons for this is that car park operators are typically not the owners of the car park and work on five to seven year-long contracts/leases. Therefore, they are reluctant to make investments that may only generate returns after their contract has ended.

One stakeholder said that if operators felt they were losing customers to nearby car parks that offered AVP, they might consider offering this service too. However, an equally likely response would be to reduce the price of parking:

"If a competitor offers AVP then the operator's response might not be to install it themselves, but rather to drop their prices. Price is always the governing factor."

Car parking professional

Another pull factor would be if AVP is offered at a premium, so that operators can charge extra. But if the price will remain the same, "it is a question of market demand and the operator will wait as long as possible before deciding to go for it" (Car parking professional).

Demand as a barrier was frequently mentioned in relation to operators – without demand operators would not invest in AVP. However, it was recognised that this is a 'chicken-and-egg' situation given that demand requires supply, which requires buy-in from operators.

Another chicken-and-egg situation was mentioned in relation to utilisation:

"Initially, you wouldn't want to close off parts of the car park for AVPs. The risk is they would remain empty because the uptake is still low, and that there would be queues to the manual parking areas. Without evidence that they are going to be used, it will be difficult to convince operators to secure off specific areas."

Car parking professional

One interviewee felt that AVs – and by extension AVP – have no added benefit for anyone except the consumer.

"Until they have to, commercial operators are not going to invest in AVP. You might get the odd one who says: 'I want this to be my flagship thing', but most operators are about as many cars in as many spaces as possible, for as much time as possible. The last thing they're going to want is 15 bays that never have any vehicles in them."

Trade association stakeholder

To get operators to invest in AVP, one would first have to demonstrate that it is working and reliable (OEM stakeholder). The trade association professional suggested that the only way to get operators on board would be to pay them for using their car parks to demonstrate the technology, while at the same time ensuring that the operators would only have to put in minimal effort. The OEM stakeholder expressed that, like with the EV industry, co-operation between vehicle manufacturers and infrastructure providers will be crucial.

3.5.2 Safety

Personal safety for pedestrians in the car park was not considered a significant worry by most interviewees. Pedestrians are already encouraged to exercise caution in car parks, and some stakeholders expected autonomous vehicles to navigate the parks more carefully than human drivers. One stakeholder suggested that the vehicles be designed to for example flash headlights or give a gentle beep in proximity to pedestrians.

"How the traffic flows in the car park is something that will have to evolve. For instance, you must consider how the AVP vehicle alerts others that it is nearby, e.g. by flashing its lights. During the interim period, when people are still unfamiliar with seeing cars without drivers, extra care will have to be taken to indicate to pedestrians that that is an autonomous vehicle."

Car parking professional

One stakeholder considered the safety of AVP, or the ability to demonstrate its safety, a key blocker to overcome.

> *"With intelligent vehicles it is difficult to show that they are safe. Car parks are hard to navigate, and any viable product will have to perform reliably. Furthermore, visibility in car parks is challenging considering how vehicle sensors are typically positioned: A human driver can see over a one metre high wall, but sensors may not be able to."*

OEM stakeholder

One interviewee mentioned that the risk of car park fires spreading quickly might increase with AVP. This is especially the case if vehicles are parked more closely together, and if they are electric and will have to make use of induction charging (Car parking professional). Another interviewee mentioned that, as with any car park, one would "need to go through various steps with local authorities and fire services" to ensure that it is safe for the public to be in the area (Local authority stakeholder).

Initially, it was thought that car parks would most likely operate with mixed traffic (e.g. both autonomous and manual parking) and that this will pose barriers, not least with regards to safety.

3.5.4 Security

Security was brought up as a potential barrier to consumer adoption. For example, the car parking professional said that customers might worry that the car does not properly lock itself after it drives off to park, or that the floor on which it parks is not blocked off from pedestrian access.

> *"Many people will have concerns and worries about the security while the car is away parking itself. For example, they may worry that the system isn't locking the car properly, and that something might get stolen from the vehicle."*

Car parking professional

At the same time, it was also noted that stopping pedestrians from accessing AVP areas would require costly investments for the car park operator.

3.6 Benefits

3.6.1 Controlled environment for AVP

Several stakeholders felt that it would be easier to gain the public's acceptance of autonomous vehicles in the car park, as opposed to on the highways. The main reason for this was the comparatively controlled area of the car park.

One stakeholder argued that "there are far fewer regulatory and social obstacles in a controlled environment such as a car park" and that the vehicles can easily be designed to signal when they are in the proximity of pedestrians (Local authority stakeholder).

3.6.2 Operator benefits

From the operator's perspective, the main benefits of AVP would either be increased revenue, or cost-savings. It was argued that revenue would increase if AVP allows for vehicles to park closer together with reduced clearance (thus increasing capacity and maximising the use of infrastructure), or if AVP was

offered at a premium. Another possibility is that AVPs can park in undesirable spots that other drivers would rarely occupy anyway.

As for cost-savings, it was felt that these would predominantly be realised if a whole floor was dedicated to AVP so that operators could save on costs like lighting, ventilation and signage, as well as fit more cars in (Trade association stakeholder). However, another stakeholder noted that AVPs will not always be able to park closer together:

> *"It depends on the layout of the car park itself. There are car parks where the distance between columns makes it hard to fit any more cars in than you currently do. Although, in principle, it is of course easier to park cars closer together with AVP. It will depend on how clever the system is in measuring the size of the vehicle and making sure that the car park itself can be optimised."*
>
> *Car parking professional*

The same stakeholder pointed out that car park walls and columns are often hit by drivers by accident, which eventually weakens the structure of the car park. If AVP vehicles can park more accurately and are less likely to collide with objects in the car park, this would reduce the number of repairs required and lead to cost savings for the operator.

A trade association stakeholder noted that, at present, most car parks are rarely utilised to full capacity and should therefore have space to accommodate AVP. This is because customers tend to opt for on-street parking and are reluctant to pay for parking. However, a car parking professional mentioned that the current trend is to reduce on-street parking, which will drive up overall demand for parking in off-street car parks. Thus, the capacity and utilisation of existing car parks will have to increase in time, necessitating solutions like AVP and other innovations.

3.6.3 Car park user benefits

The main user benefits mentioned were the increased convenience of not having to manoeuvre the car into a parking spot, and the comfort of not having to walk into/out of a car park that might be dimly lit or dirty. If payment was made easier, e.g. if the AV paid for itself, this was also considered an added benefit for customers. It was argued that some customers, such as commuters and business travellers, may be attracted to the time-savings offered by AVP, while others "wouldn't use it if it increases the cost even a little" (Car parking professional).

Another view was that AVP could also benefit people who would continue to park their vehicles manually, as the AVP service could fill up undesirable spots, leaving the more attractive ones to other drivers.

> *"There are many people that stop using car parks after a certain time, because they know that the only spaces that will be available are at the top and they don't like driving to get to those levels. Using those spaces for AVP would reduce the need for people to park elsewhere."*
>
> *Car parking professional*

One interviewee, the OEM, felt an infrastructure heavy AVP solution is more beneficial to customers, as it would keep the costs of the vehicle down. For fleets in particular, it would be important that vehicles are not too expensive.

3.7 Summary of Interview Findings

This section has presented the findings from the stakeholder interviews carried out as part of the AVP project. The interviews sought to understand challenges and benefits of AVP from the perspective of car park professionals and OEMs. Some of the key takeaways are:

- An assumed lack of car park operator buy-in was identified as a key blocker to AVP. Although there may be some benefits of AVP to the operators (e.g. increased capacity), it was still considered difficult to get buy-in from this group, in particular if there is little or no evidence that the service will increase customer traffic
- An infrastructure 'light' AVP solution will be more attractive to car park operators, as it requires little to no investment on their behalf
- It is imperative that uncertainties around liability and insurance are resolved, from the perspectives of both users and car park operators
- AVP could have a positive impact on congestion and could reduce pollution levels

4. Survey Results

In December 2018, we surveyed 1025 people across the UK about their current experience of parking, their views on valet parking, and their views on autonomous valet parking. The weighted[16] results are summarised below.

4.1 Current Parking

4.1.1 Indoor car park usage

On-street and outdoor car parks were by far the most popular places for parking in the sampled population. On average, 21% of the participants regularly made use of an indoor underground car park, and 27% made regular use of an indoor, multi-storey car park.

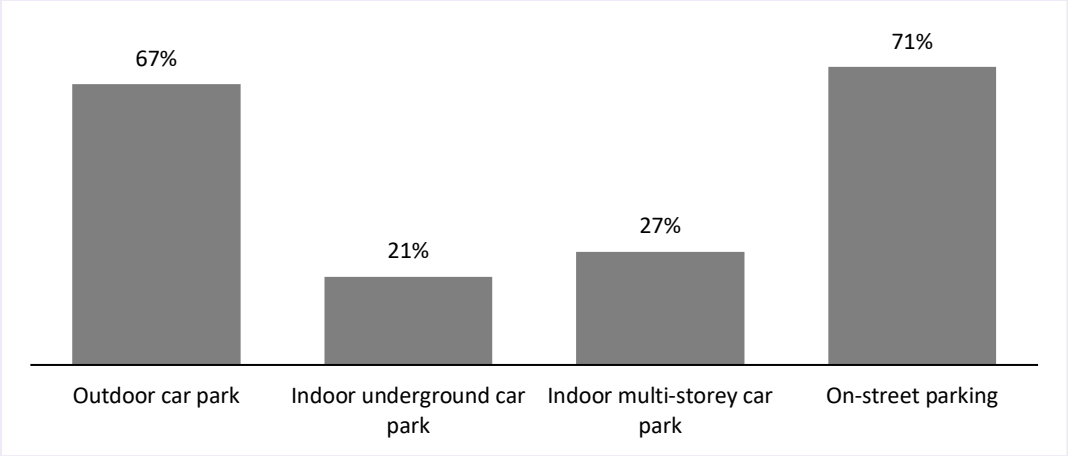

FIGURE 4.1: Use of different parking facilities once per week or more frequent, in percentages (n=1025, weighted base)

The most common reason for not using an indoor car park was that there was a lack of need, with 72% of respondents citing this as a reason. There was a significant difference between men and women's likelihood to respond that they did not use indoor car parks because they did not like it, or because they chose not to. 20% of women stated this as a reason, compared to 11% of men.

[16] Data was weighted based on gender, age and UK country of residence. Age and gender weighting were based on figures from the National Travel Survey, and UK country weighting was based on figures from the Office of National Statistics.

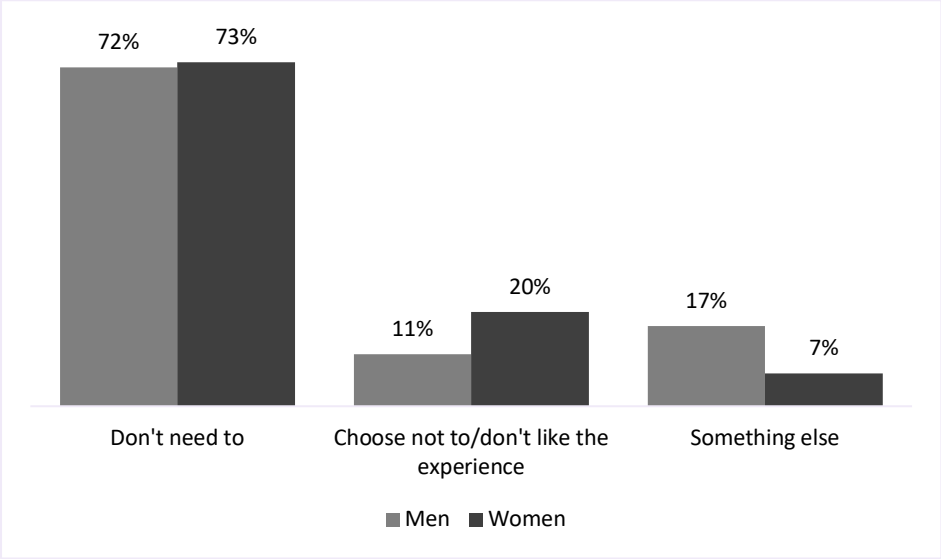

FIGURE 4.2: Reasons for not using indoor car parks, split by gender (n=224, weighted)

The most common purpose of the last trip involving indoor car parking was to go shopping. Women had used indoor car parks for this reason to a significantly larger extent than men (74% of women compared to 67% of men). Compared to all regular car park users, 17-29 year-olds were significantly more likely to have used an indoor car park to attend a social event (30% of 17-29 year-olds, compared to 19% of all) and to go to work (20% of 17-29 year-olds compared to 13% of all).

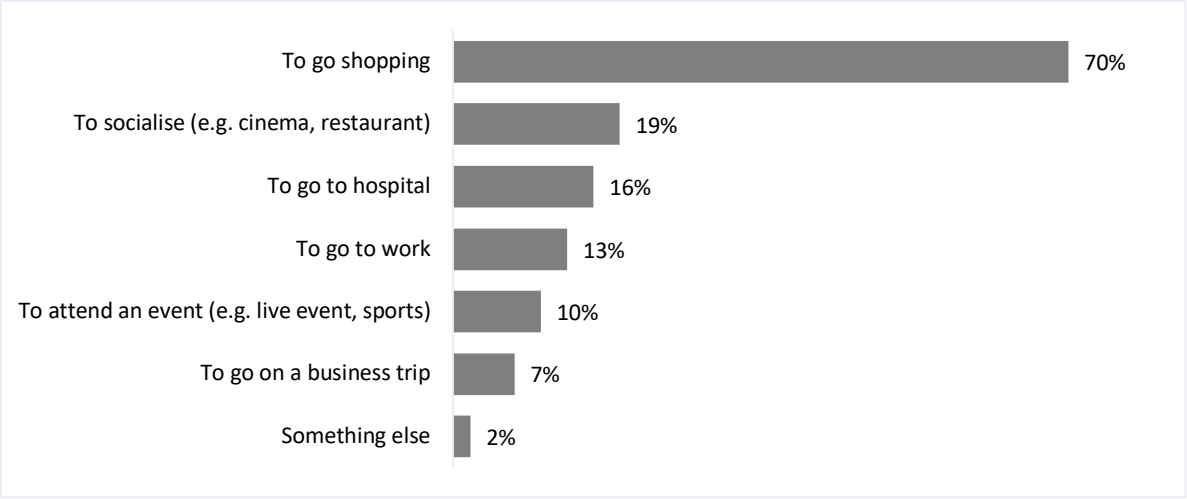

FIGURE 4.3: Purpose of most recent trip that included indoor parking (N=801, weighted)

The average self-estimated time to park during the most recent use of an indoor car park was 16 minutes but most participants (33%) estimated that the parking had taken between 5-10 minutes.

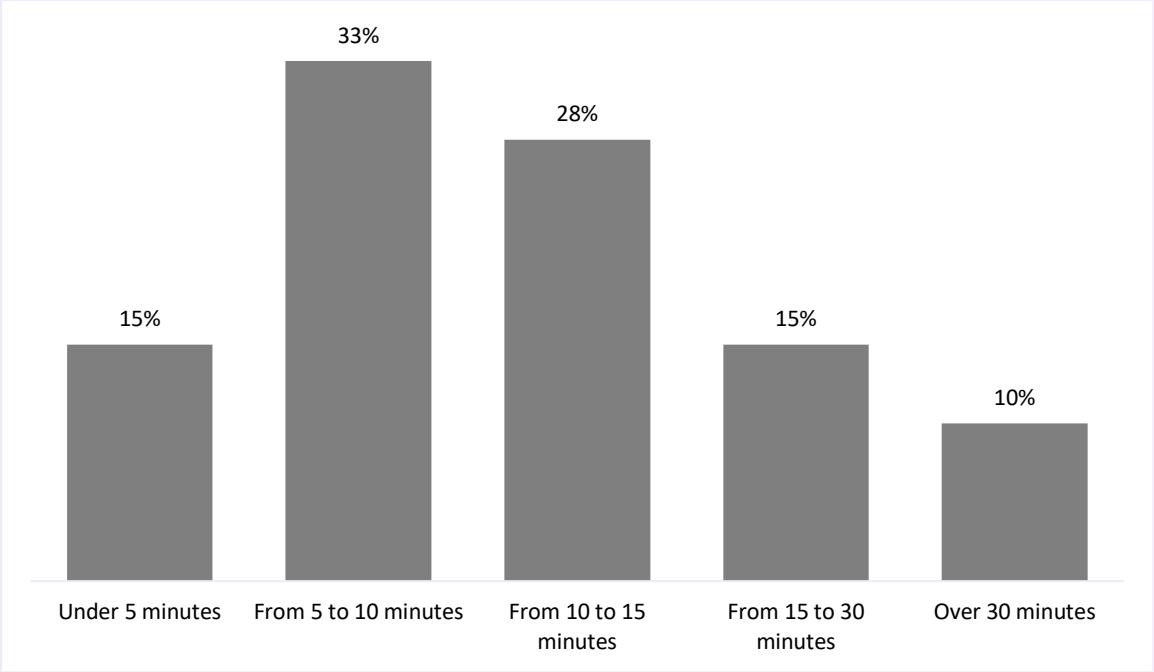

FIGURE 4.4: Average estimated time to park at the indoor car park, in percentages (n=801, weighted)

When asked about the ease of carrying out different steps of parking, respondents stated that finding a space within the car park was the least easy.

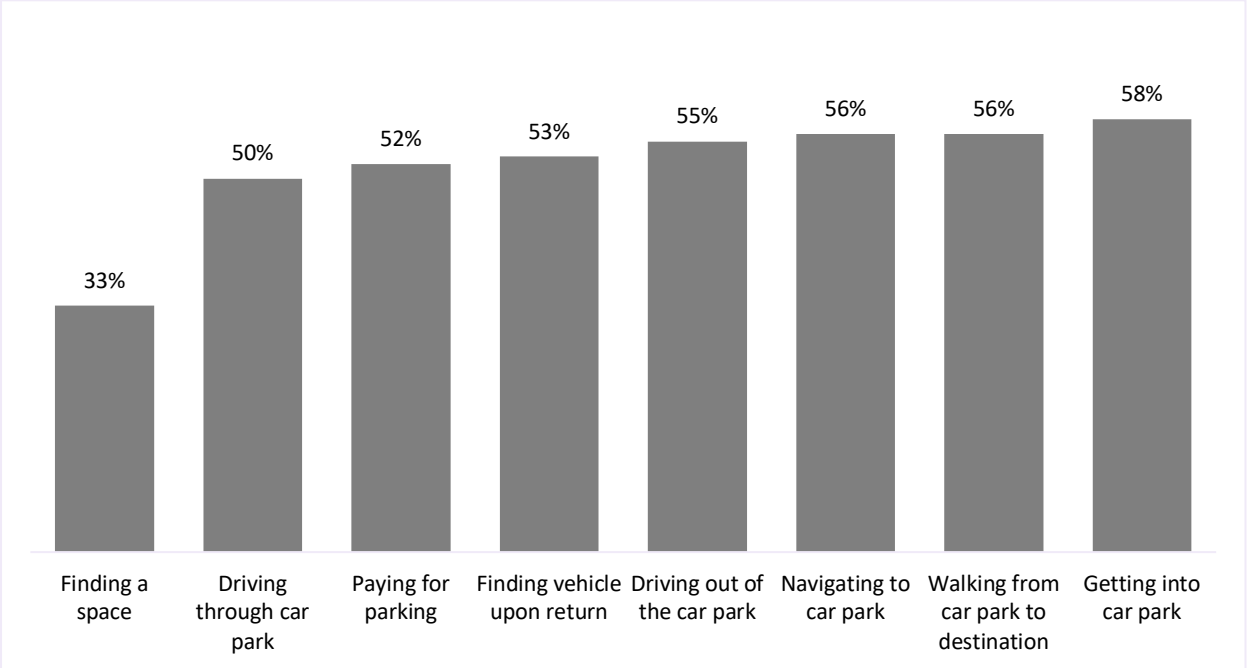

FIGURE 4.5: Percentage of respondents who found the following parking steps to be easy or very easy to carry out during recent indoor car parking experience (n=801, weighted)

There was a clear difference between 17-29 year-olds and the rest of the sample population in the perceived ease of indoor car parking - younger respondents felt all different steps of indoor car parking were significantly less easy compared to the overall sample.

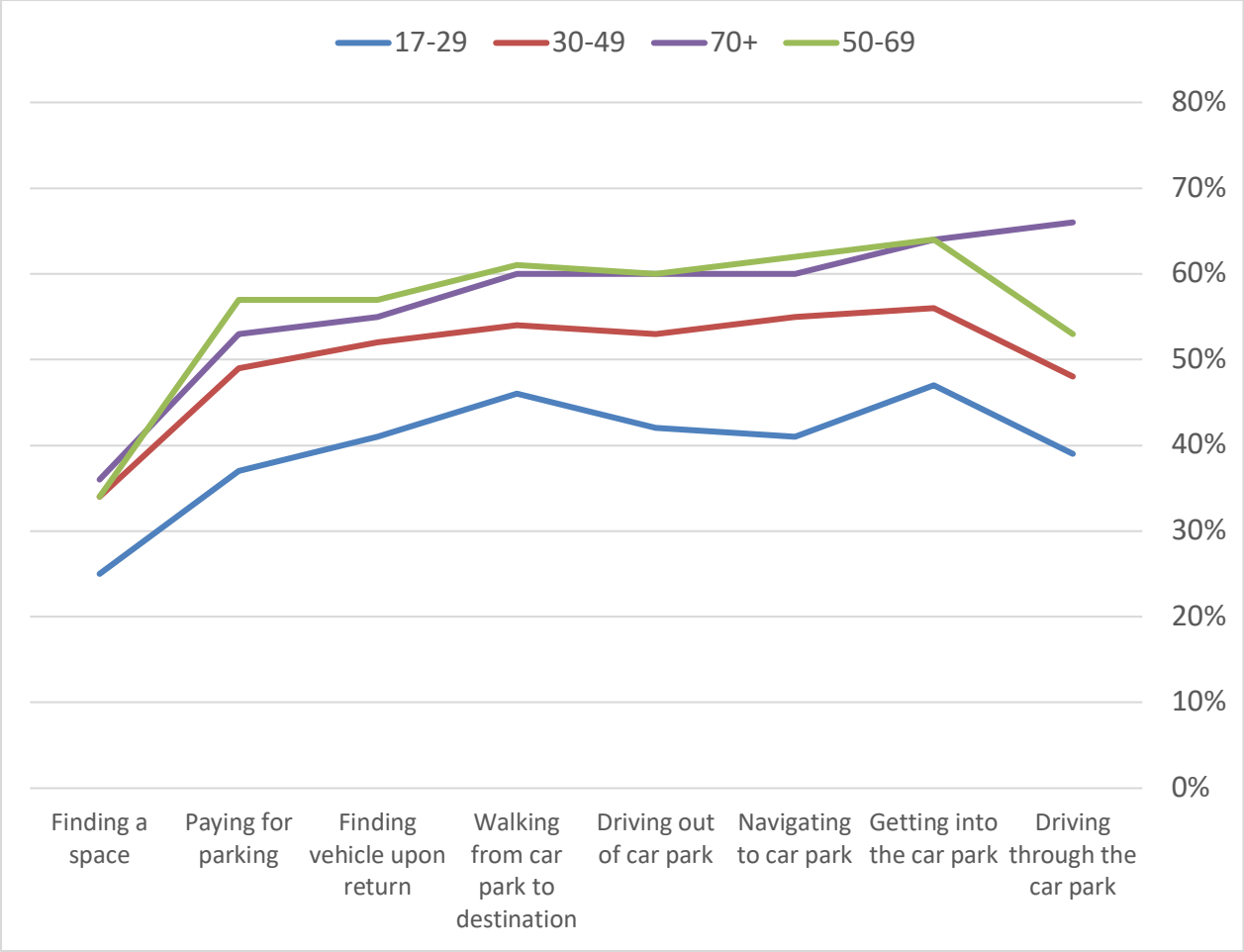

FIGURE 4.6: Percentage of respondents who found the following parking steps to be easy or very easy to carry out during recent indoor car parking experience, split by age (n=801, weighted)

Significant differences were also found between those who had used valet parking and those who had not. Compared to respondents with no experience of valet parking, those who had used valet parking stated that it was less easy to:

- Navigate to the car park
- Get into the car park
- Walk from the car park to the end destination
- Find the vehicle upon return
- Drive out of the car park

4.1.2 Driving assistance technology and online parking applications

When asked whether their car has any of six different driver-assist features, just over half of respondents (54%) were not aware that their current vehicle was equipped with any of these. The percentage was significantly higher for women (59% compared to 50% for men). It is worth pointing out that drivers may not be aware of their vehicle's functionalities.

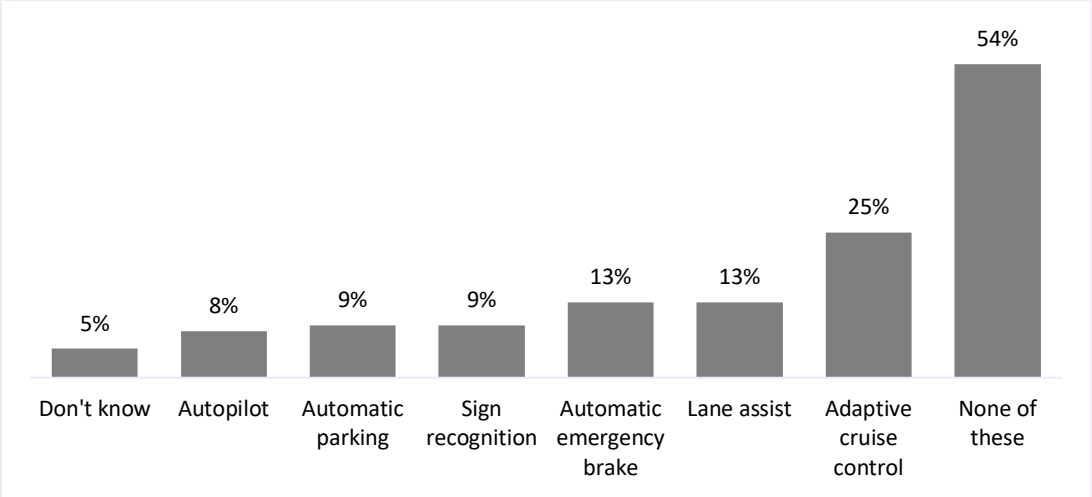

FIGURE 4.7: Percentage of respondents availability of driver assistance technology in current vehicle (n=1025, weighted)

A significantly smaller proportion of women (6%) than men (12%) stated that their vehicle was equipped with automatic parking functionality.

73% of the population believed automatic parking functionality would be useful or very useful. There was no significant difference between different genders, age groups or levels of experience of using indoor car parks.

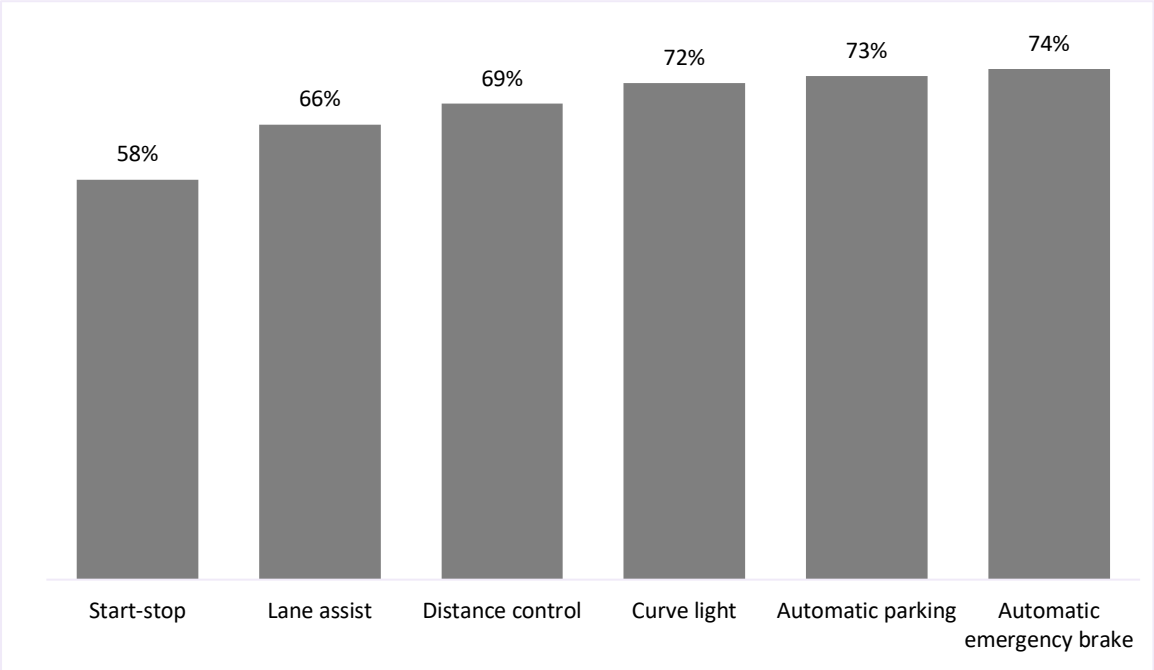

FIGURE 4.8: Percentage of respondents who believe the following driver assist features are useful or very useful (n=1025, weighted)

Men were significantly more likely than women to have used mobile or online applications to find, book and reserve parking.

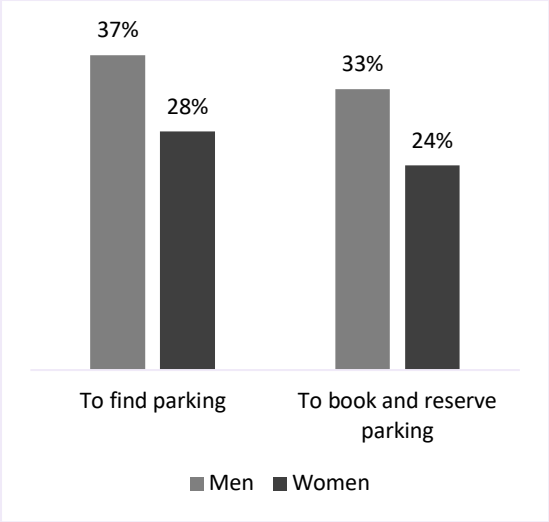

FIGURE: 4.9: Percentage of respondents who have used a mobile application or gone online to carry out parking tasks, split by gender (n=1025, weighted)

Similarly, younger respondents had more experience of using parking related apps or online services than older respondents.

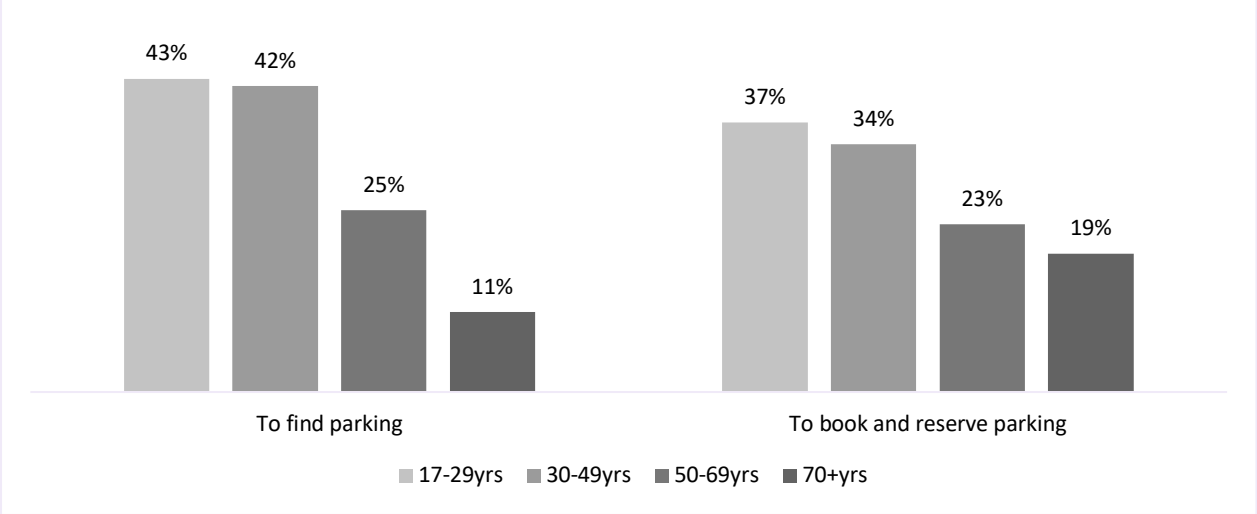

FIGURE 4.10: Percentage of respondents who have used a mobile application or gone online to carry out parking tasks, split by age (n=1025, weighted)

4.1.3 Valet parking

Overall, 42% of drivers have previously used a valet parking service. Amongst users of the service this was most common at airports (46%) or hotels (46%). Age appeared to be the biggest factor impacting valet parking use, with highest levels of use found in the 17-29 age group (64%). The survey data showed that the typical valet parking user is a higher income earning male living in an urban area who uses indoor car parks frequently.

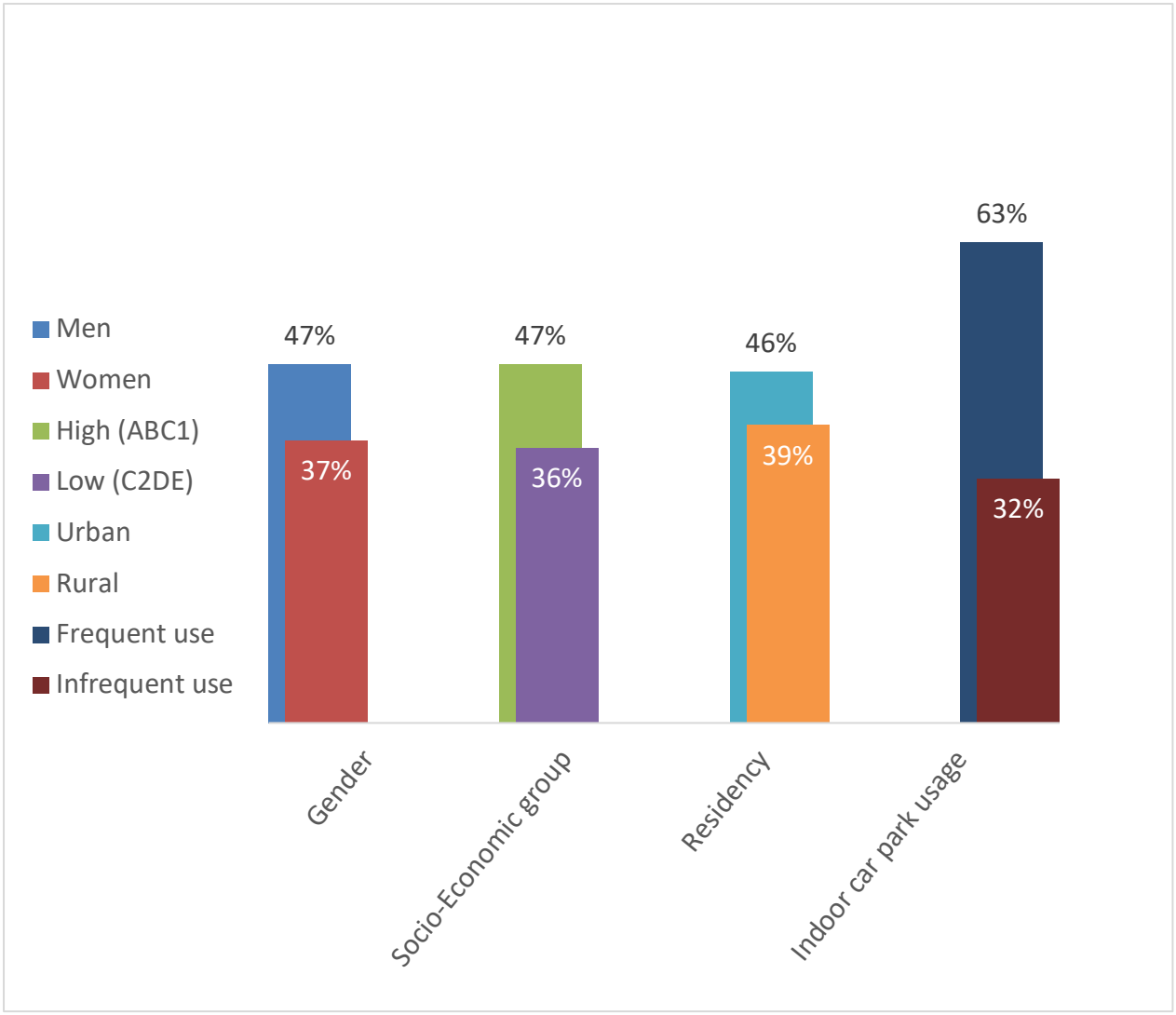

FIGURE 4.11: Percentage of respondents who have used valet parking services (n=1025, weighted)

44% of respondents stated that they would use a valet parking service if it did not cost them anything extra. There were no significant differences by gender or age group, however frequent indoor car park users were significantly more likely to agree (48%) than non-frequent users (40%). Those who indicated they would allow their car to take control of parking were also more likely than the overall population to use this service (50%). Amongst previous valet parking service users, potential take up was 51% but interestingly 21% were unlikely to use it at an indoor car park.

The biggest worries respondents had about valet parking were that their vehicle would get damaged (48%), or that it would be driven somewhere else than to be parked (48%). 46% of respondents agreed that valet parking would alleviate parking related stress. There were no significant differences by gender or age group in terms of worries or perceived benefits of valet parking.

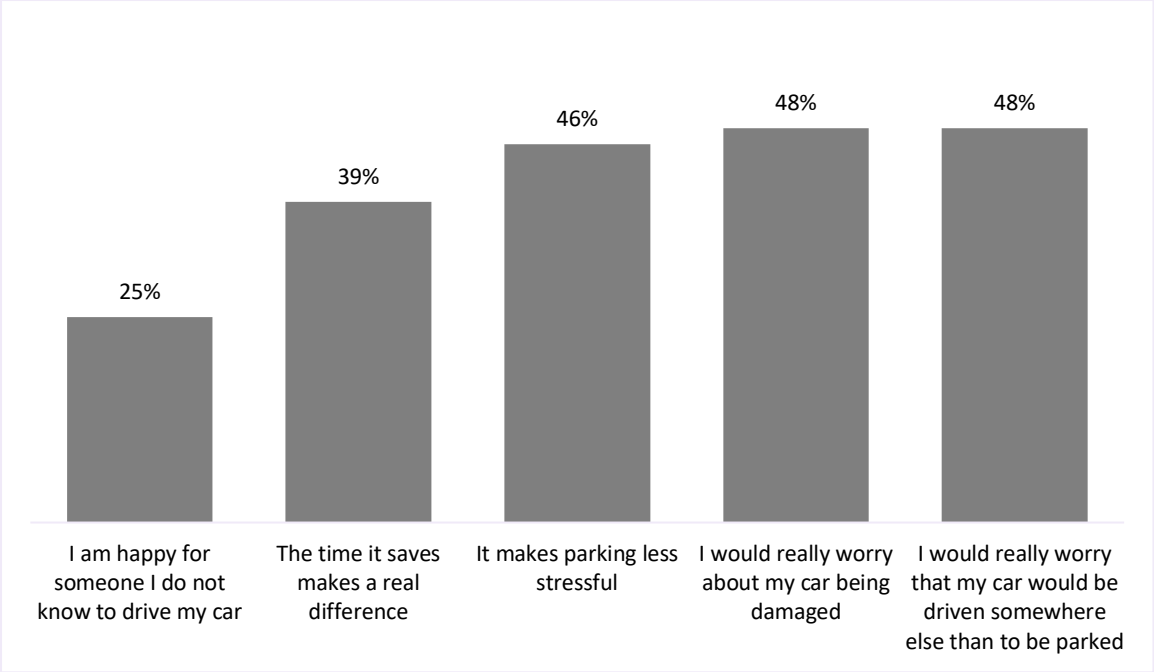

FIGURE 4.12: Percentage of respondents who agree or strongly agree to statements about valet parking (n=1025, weighted)

Frequent indoor car park users had fewer concerns about, and saw more benefits of, valet parking than non-frequent car park users, but they were slightly more worried and less positive about it compared to respondents who had used valet parking in the past.

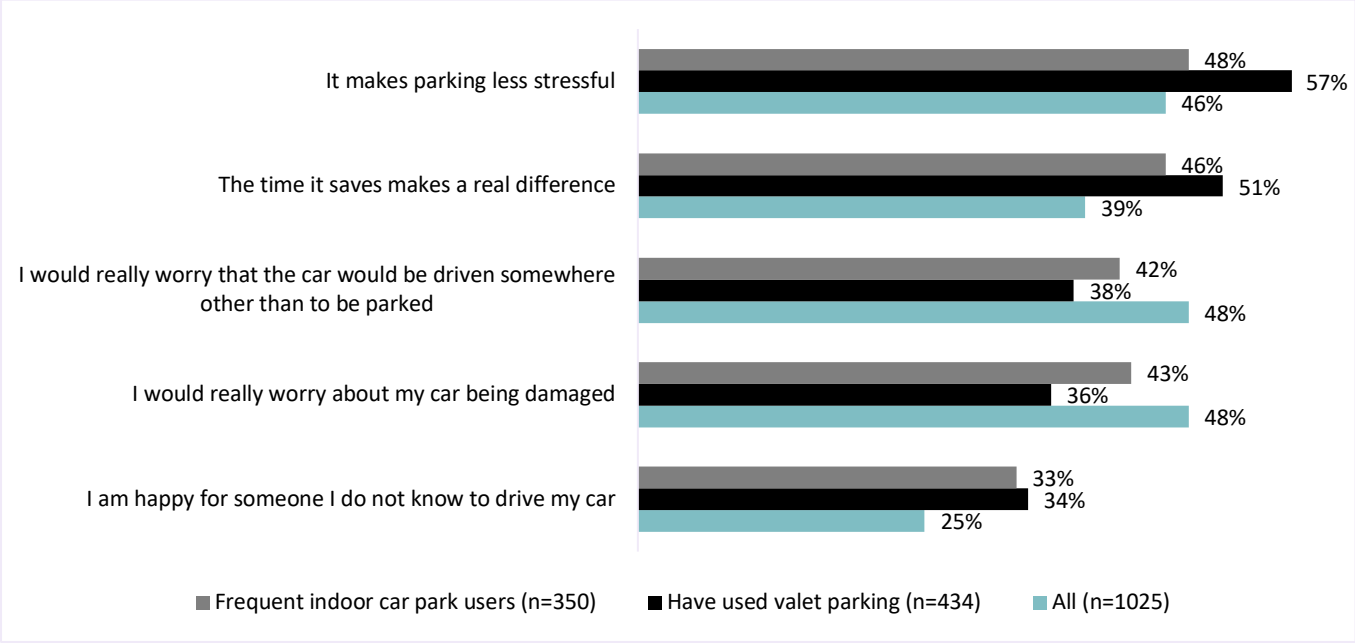

FIGURE 4.13: Percentage of respondent who agree or strongly agree to the following statements, split by different parking usage (n in legend, weighted)

4.2 Autonomous Valet Parking

4.2.1 Vehicle taking over control

Respondents were asked when they would be most likely to allow their vehicle to take over control. "When parking" was the most common response (42%), whilst 17% would not allow the vehicle to take control at any time. Men were more willing than women to allow the vehicle to take over in fluid traffic on a motorway and in urban traffic.

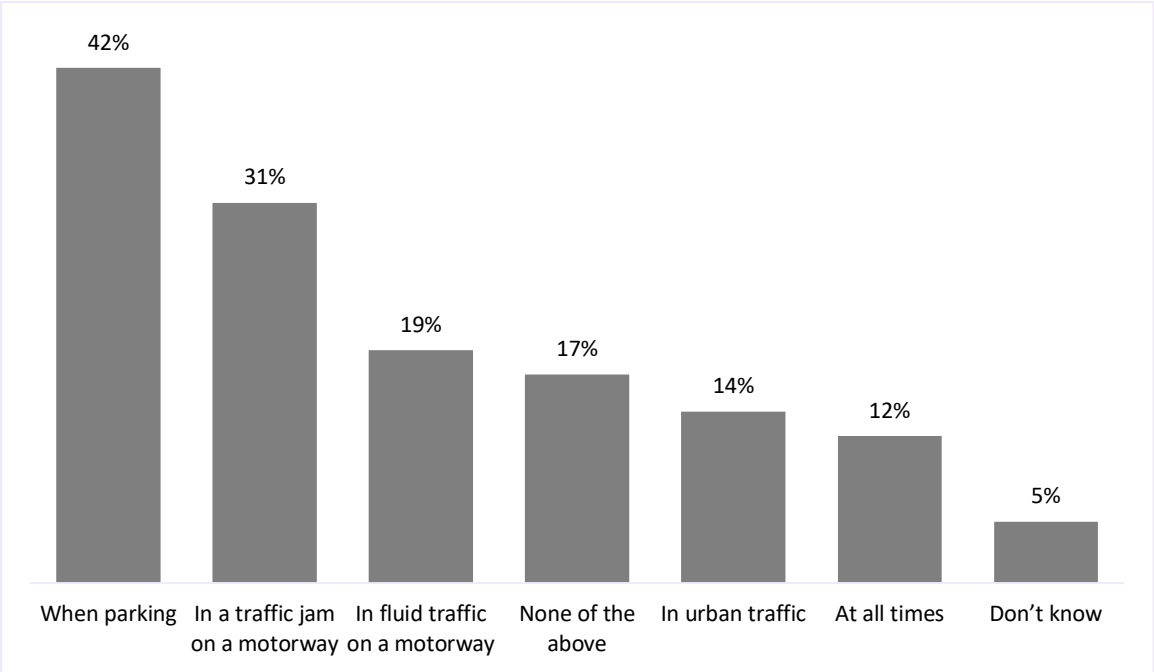

FIGURE 4.14: Percentage of respondents who would allow their vehicle to take control of driving in the following situations (n=1025, weighted)

4.2.2 Desire to use

Of all respondents, 40% stated that they think AVP is a good idea but would need to know more about it before deciding whether they would like to use it. 21% would like to have AVP now, while 19% stated that they were unlikely to ever want to use it. This profile resembles the size of the five technology adoption segments (innovators and early adopters (16%), early majority (34%), late majority (34%) and laggards (16%))[17].

[17] https://ondigitalmarketing.com/learn/odm/foundations/5-customer-segments-technology-adoption/

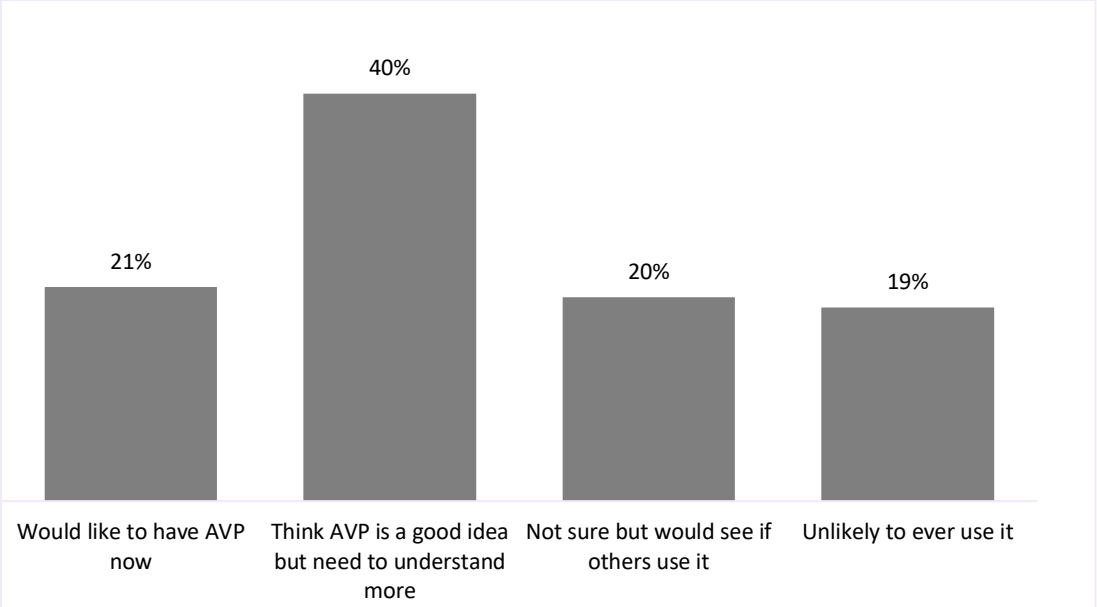

FIGURE 4.15: Attitudes to AVP, percentages (n=1025, weighted)

A lower percentage of women (18%) than men (23%) stated that they would like to have AVP now. This could be compared to attitudes to valet parking, where a higher percentage of women than men stated that they would like to use valet parking if it did not cost anything extra. Female drivers were more likely than their male counterparts to want to wait to see if others use AVP before committing themselves (23% vs 17%).

Younger respondents were more positive towards AVP than older respondents. 28% of those aged 17-29 would like to have this service now, compared to 9% of those aged 70 or over and 16% of 50-69 year olds.

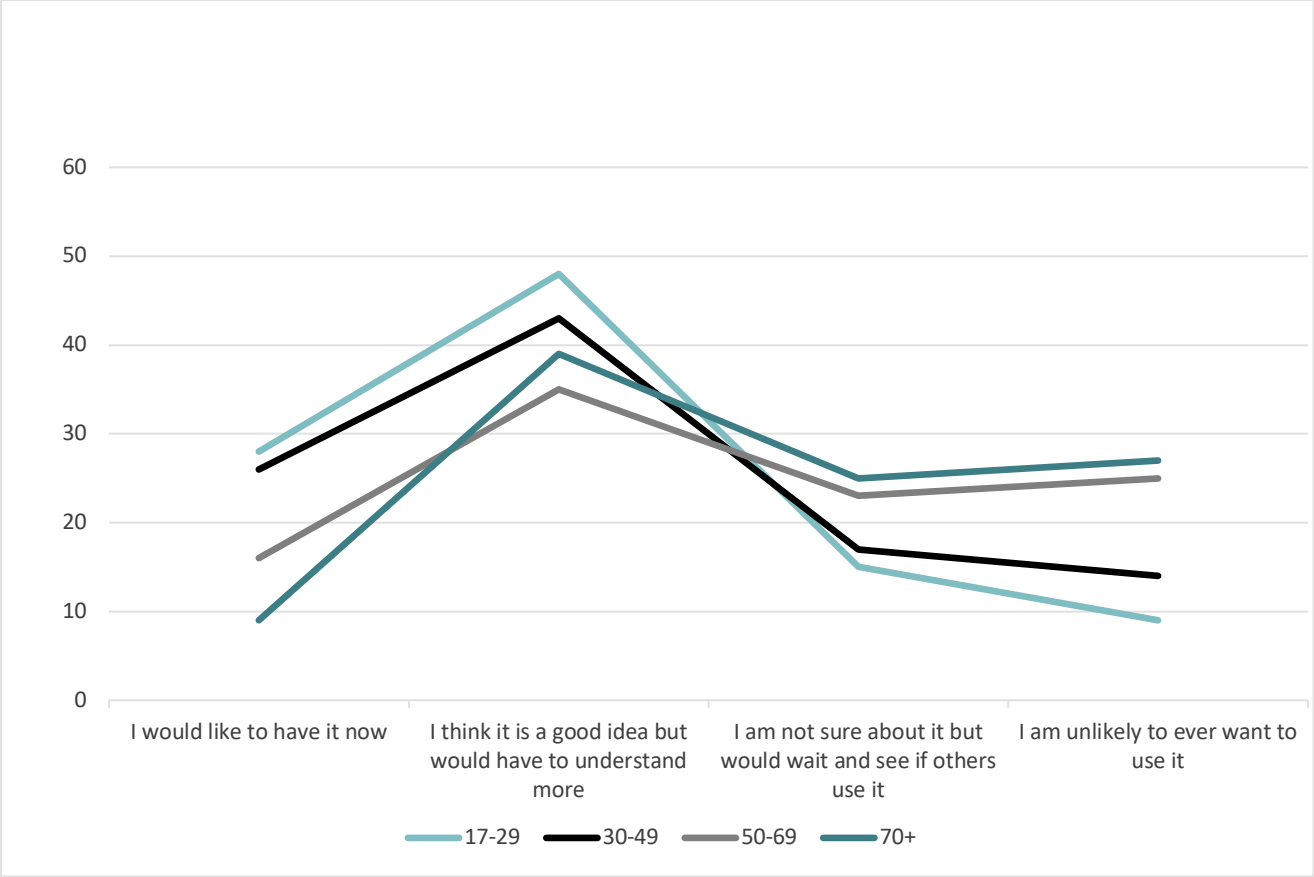

FIGURE 4.16: Attitudes to vehicle driving away and parking itself after entering an indoor car park, percentage of respondents agreeing, split by age (n=1025, weighted)

Respondents were asked whether they would be more likely to use a human operated valet parking service than an automated one. Overall 21% would prefer autonomous, 48% a human and 31% were not sure. There were significant differences between different genders, age-groups, place of residence, experience of valet parking, and driving assistance feature ownership:

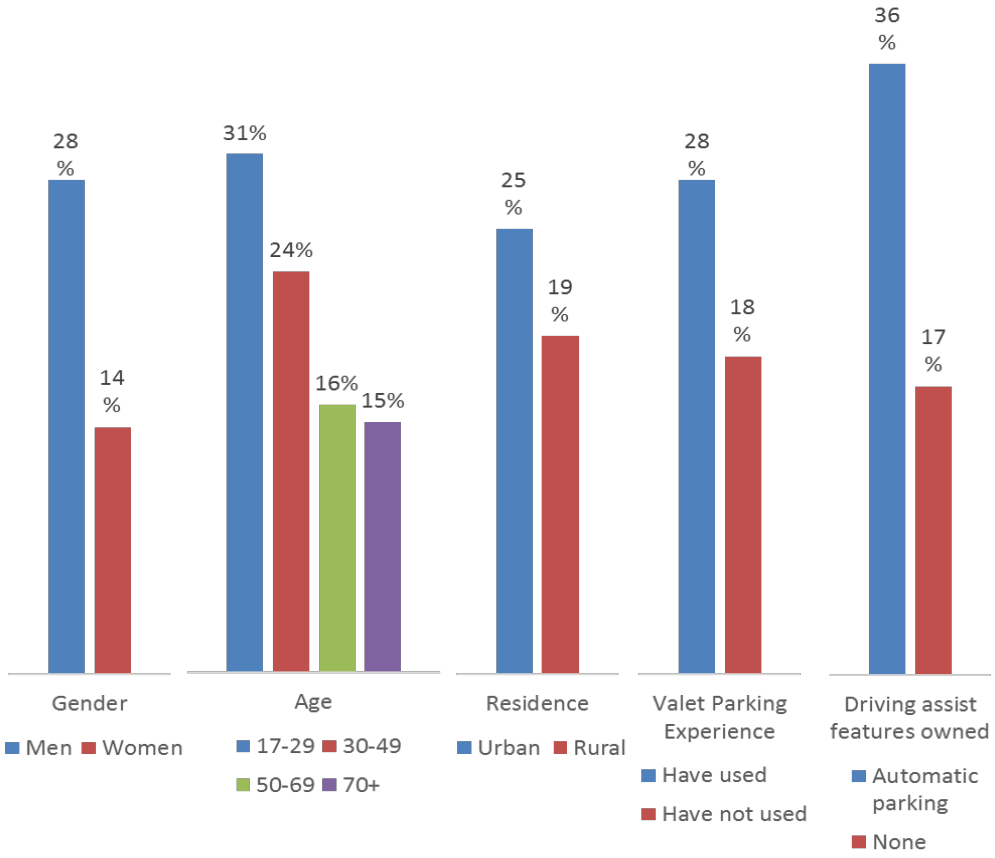

FIGURE 4.17: Percentage of respondents who are more likely to use an auto-valet parking service than a human operated service, split by different categories (n=variable)

The highest proportion of respondents who would choose AVP over human valet parking was found among those who already owned automatic parking features (36%).

Characteristics of respondents who own automatic parking (AP) features:

- 16% of those who have used valet parking services own AP features
- 15% of people aged 17-29 years old own AP features
- 15% of frequent indoor car park users own AP features
- 12% of men (6% of women) own AP features
- 11% of medium-high income earners (7% of medium-low income earners) own AP features

4.2.3 Benefits and disbenefits

Parking related stress reduction was the biggest benefit that respondents who would be willing to use an AVP service could see (58%). This was closely followed by the view that it would make parking with children easier (52%). There were no significant differences between male and female attitudes. The results can be compared to the perceived benefits of valet parking (human or automated) in the overall sample (n=1025). Here, 39% of men and women responded that the time savings would make a difference, and 46% said it would make parking less stressful.

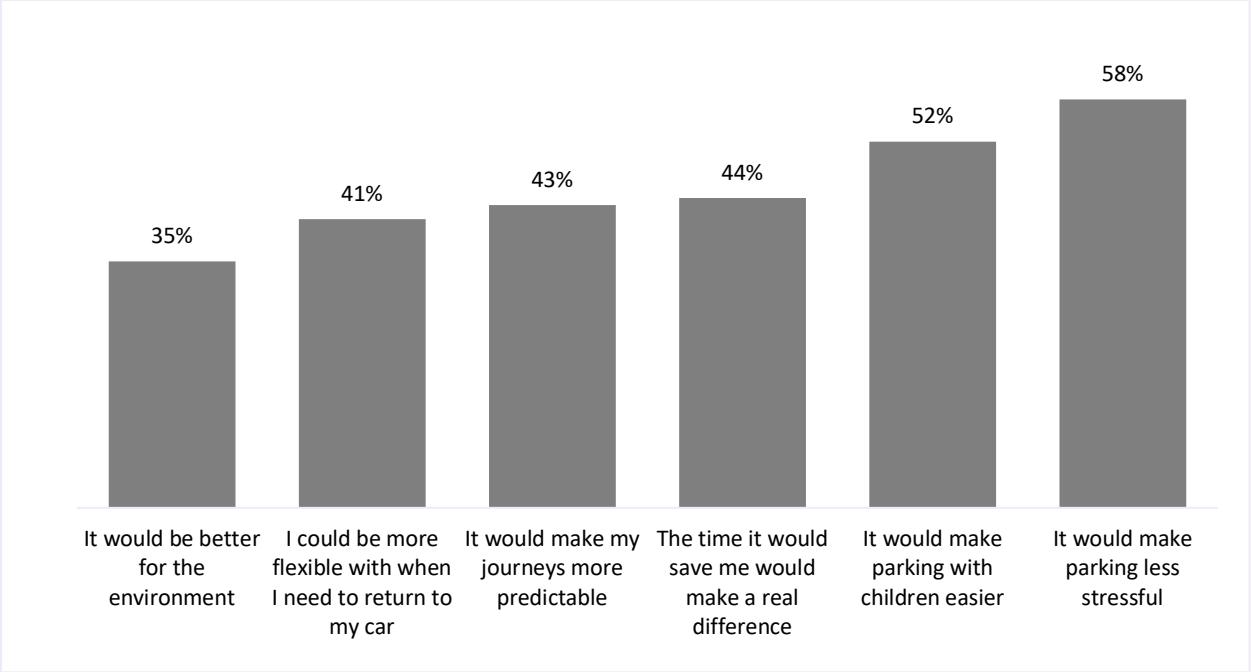

FIGURE 4.18: Percentage of respondents willing to use an AVP service who agree or strongly agree to the following statements (n=832, weighted)

Some verbatim benefits reported by respondents were:

"Being disabled it would make parking much easier."

"Not having to walk my 4-year old, or push my husband's wheelchair, through a car park"

"The main benefit would be not driving up and down the car park, looking for a space with impatient drivers behind you."

"Less stress of having to find a parking spot, and park while other people could be watching"

The biggest concern among respondents was that the car would be damaged after driving away to park (48%). This was followed by a worry around how long it would take to return the vehicle after parking (43%).

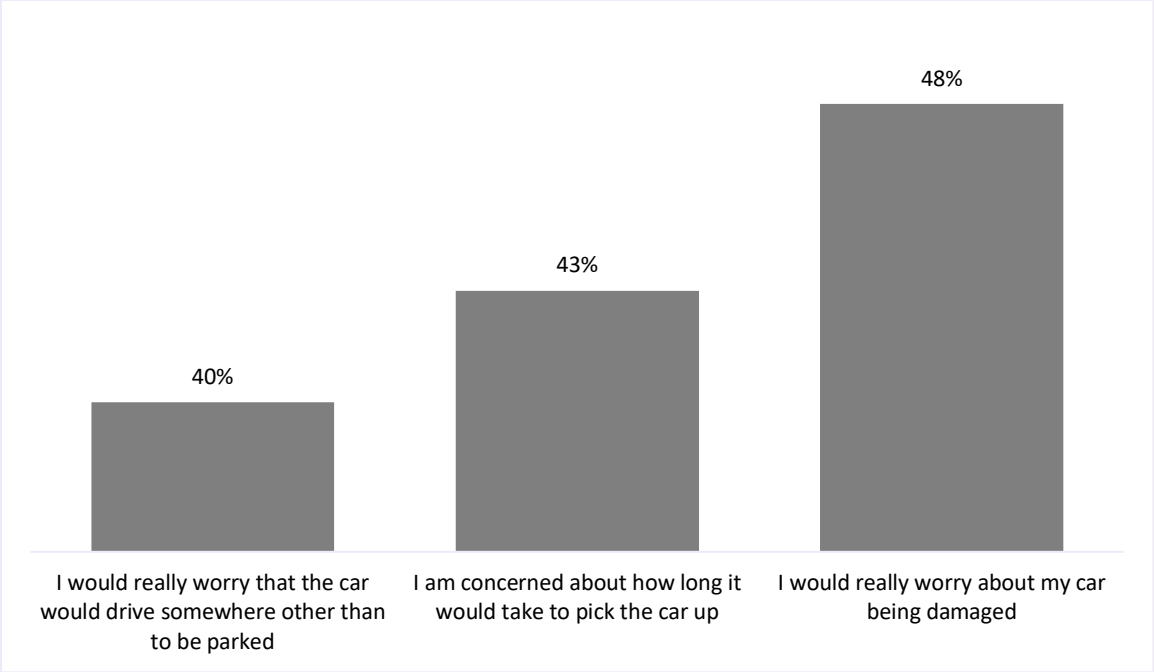

FIGURE 4.19: Percentage of respondents willing to use an AVP service who agree or strongly agree to the following statements (n=832, weighted)

Some verbatim disbenefits and worries reported by respondents were:

"It's an untrusted system at the moment. Who is responsible for any damage?"

"If extra cost was implemented it would be a no-no."

"I wouldn't know where the car was parked."

"I hate the idea of the car doing something itself. I have a computer background and don't trust computers... they go wrong!"

"If I need to get things out of the car (children, bags, etc) I'd worry about holding up other drivers behind me."

"Do I really need it, and would it make me lazy?"

"Not knowing how the insurance works if any damage occurs is a worry."

"I'd be worried if other people are driving [in the car park], rather than all cars being automatic."

4.2.4 AVP zone

Most respondents (43%) preferred that the AVP service was designed so that the vehicle is completely segregated from non-AVPs throughout the whole operation. Women were more likely than men to prefer that the vehicle would park as close to the drop-off zone as possible (37% vs 27%), while men were more likely than women to prefer that the vehicle does not come in contact with human-operated vehicles throughout the parking operation (47% vs 37%).

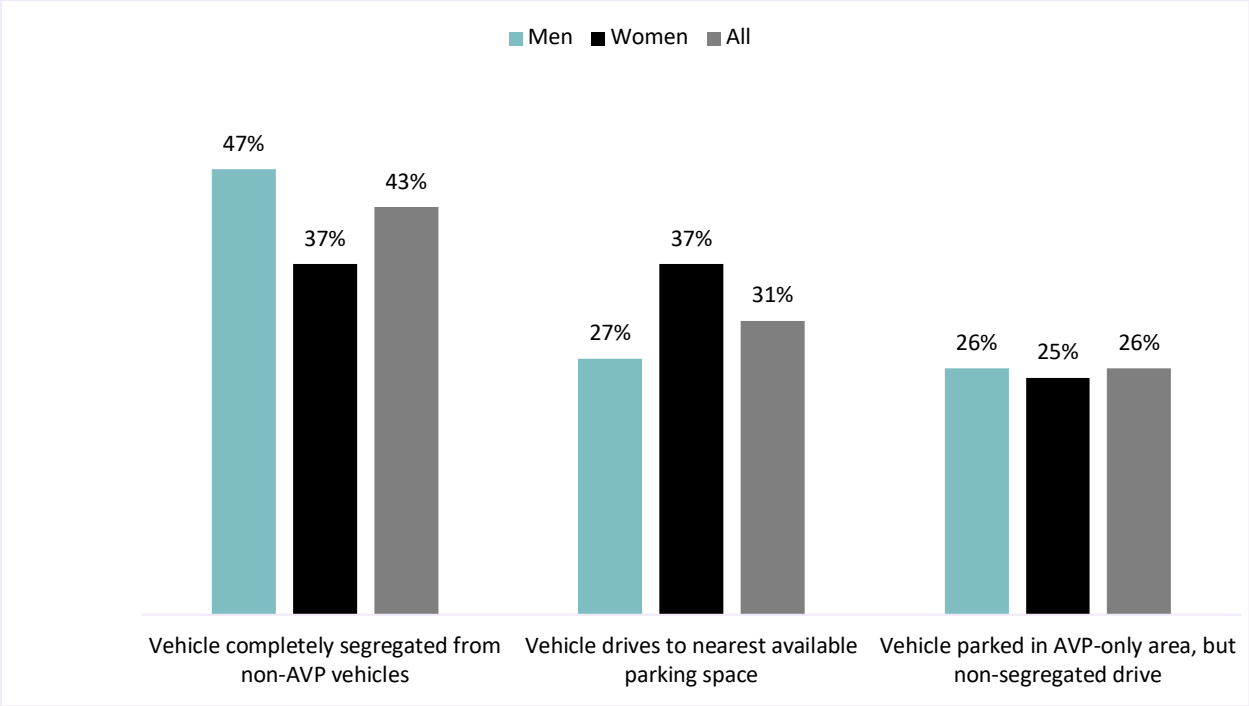

FIGURE 4.20: Most attractive option for AV Parking among respondents willing to use AVP service, in percentages (n=832, weighted)

Those who have used valet parking services before were more likely to want the AVP service to be completely segregated (50%). For non-valet parking users, driving to the nearest available space was marginally the most popular option (39%).

4.2.5 Information preferences

Of respondents who would consider AVP (n=832), 66% would like information or updates after dropping off their car. The type of information was recorded verbatim, and included updates about:

- Location of vehicle, including where it is parked (some preferred continuous updates)
- Whether the vehicle is locked
- When the vehicle is parked
- Damage/Accidents
- Parking charges
- Where/how to collect the car
- Nearby incidents and distance to own vehicle
- Distance between own vehicle and cars parked around it

There were several mentions of receiving information in image or video form, e.g. photos or CCTV footage of the parked vehicle.

4.2.6 Willingness-to-pay

Of those who would be willing to use an AVP service, 52% would not be willing to pay extra. There was no significant variation in willingness to pay between:

- Men and women
- Rural and urban residents
- Different socioeconomic groups

- Frequent vs infrequent indoor car park users
- Different age groups

Those who had not used valet parking in the past were less willing to pay extra for AVP (56% versus 48% of those who have used valet parking). In addition, people who owned a vehicle with automatic parking features were more willing to pay extra for AVP than people who did not own any driving assist features.

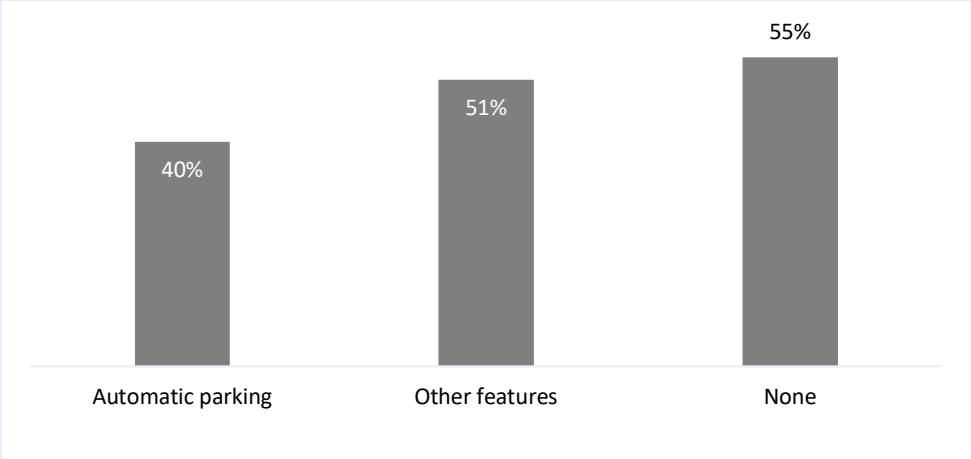

FIGURE 4.21: Percentage of respondents who would not be willing to pay extra for AVP, split by features owned (n=832, weighted)

4.3 Summary of Survey Findings

This survey examined UK residents' current parking experiences, their familiarity with parking assistance technology, and their attitudes to autonomous valet parking.

Some of the key findings were that:

- 44% of women, and 41% of men would be willing to allow their vehicle to take control of parking
- 21% of respondents would like to have AVP now, with another 40% agreeing that it is a good idea but they would need to understand more
- Over half of those who would consider using AVP thought it would make parking less stressful, and that it would make parking with children easier
- The biggest worry among those who would consider using AVP was that their vehicle would be damaged followed by the time taken to pick the vehicle up afterwards
- 66% of respondents would like information or updates after dropping off their car
- 52% of those who would consider using AVP would not be willing to pay extra for this service

We also found some interesting differences between different groups of respondents.

- The younger drivers in our sample felt indoor parking was more difficult than older age groups, which suggests that they could benefit more from an AVP service than others. Younger drivers were also more positive about new technology and had more experience of using online apps and services to book and pay for parking. They were the most likely to respond that they would like to have AVP now, and that they would be willing to pay extra for the service

- Pre-existing experience of automated parking features appeared to positively influence perceptions of AVP. Respondents who already own a vehicle with automatic parking functionality were much more likely than others to state that they would prefer an AVP service over a human operated one. This group was also more likely to state that they would be willing to pay extra for an AVP service

5. Focus Group Findings

Two focus groups with car park users were conducted to explore:

- Current car park use
- Experience of using car parks
- Experience of using valet parking services
- Attitudes toward autonomous valet parking

The first focus group took place in Guildford in November 2018 and the second focus group was held in Milton Keynes in January 2019. All participants were car drivers who regularly used indoor car parks. They were of different ages and the gender balance was approximately 50/50.

Focus groups were held after work hours and lasted for about 90 minutes. Each group had 8 participants, excluding the two researchers. In the Guildford focus group, participants were asked targeted questions about the Farnham Road car park in Guildford town centre. In Milton Keynes, focus group participants were invited to share experiences about any indoor car park they had used. To explore participants' views on the valet parking technology, participants were presented with a scenario where the car would be driven into a car park and 'dropped off' before the AVP technology parked the car. This was to steer participants away from picturing a service that would for example allow them to be dropped off at any place (e.g. directly outside of shops), or that the vehicle could park at places other than an indoor car park.

5.1 Current Use

5.1.1 Parking pain points

Focus group participants disclosed several parking related pain points. These are recorded in the table below.

Payment	- Broken ticket machines - Poor technology, e.g. touch sensors not working - Queuing for tickets - Receiving parking fine due to slow/dysfunctional payment process - Machine only accepts cash OR card - Absence of staff to speak with when experiencing payment problems - Advance payments with no refunds – either overpaying or forced to rush back in time to collect the vehicle - Having to manually check the vehicle in and out - Having to input hard-to-remember information to receive ticket, e.g. licence plate number - Minimum charge - Poorly designed ticket machine interfaces
Car park layout	- Difficult to enter and exit by foot, e.g. only access point through emergency exit - Pillars and bollards that are difficult to navigate around - Too small parking bays - Narrow and hard to navigate access roads - Poor location of disabled/family access - Poorly rationed allocation of parking spots for people with disability and families - Poor visibility e.g. around corners
Navigation	- Poor signage and markings - Unclear entry and exit rules - Knowing there are available spaces, but not knowing where they are

	- Not knowing how to get to the next level of the car park
Car park condition	- Poor lighting - Pot holes - Dirty - Lack of CCTV
People	- Slow to park drivers holding others up - Space stealing - Pedestrians walking in the way - People ignoring signs - Children and adults opening doors carelessly and scratching adjacent car - Parking with children or dependents in the vehicle
Other	- Overcrowding and queues - High cost - Accessible for members of the public who have no business in the car park - Confusing and often changing rules - Lack of information and updates when rules change

FIGURE 5.1: Indoor car parking pain points

5.1.2 Ideal parking

When participants were asked about what the ideal indoor car parking experience would look like, they offered the following:

Cost and Payment	- Free or inexpensive - Ticket free parking - Number plate recognition - Lots of pay machines - Variety of payment options, incl. contactless and option to pay by phone - Pay on exit
Layout/Navigation	- Indication of available spaces - Layout easy to navigate - Sufficient parent/child spaces - Big parking spaces
Other	- Not having to do the actual parking yourself, e.g. assisted parking - CCTV - Well-lit and clean - Close to destination - Passengers that help find empty space

FIGURE 5.2: Elements of ideal car parking

5.1.3 Parking assistance technology

Parking assistance technology was considered useful by many, in particular for those who find parking difficult.

"Reverse parking assistance is really good if you have mobility issues."

Some felt parking assistance was only for those who have a 'problem' with parking.

"If you don't have a problem with parking, you wouldn't use parking assistance features even if they were available."

There was also a fear parking assistance made you lazy and would lead to skill deterioration.

"I would not be without reverse sensors, but it makes me quite lazy. I don't know if I could reverse park without them anymore."

One participant mentioned that the technology typically carries out the parking routine more slowly than a human driver would, which means people queuing behind might have to wait longer.

"Auto-parallel parking is very slow, and everyone looks at you while your car tries to park itself."

5.1.4 Time to park

The time it would take to park was hard to predict, and many added a buffer – especially if they needed to be somewhere on a certain time

"I would leave a ten minute buffer for parking if I had to catch a train. You can do an awful lot of circulating in that time. But, of course, the reason I'm there is I must catch a train and that's when the stress starts kicking in. I begin thinking of how to get out of the car park, how long it will take to get a ticket, and so on…"

"It can take anything from a few minutes to forever."

"I always struggle with queues, and usually consider going somewhere else when I see them. You can't predict how long it will be"

5.1.5 Valet parking

Those who had used valet parking tended to be positive about the experience:

- It made travelling with luggage and dependents easy
- There was no need to remember where the car was parked

Most had used it at hotels or airports and saw it as a one-off 'treat.'

"At airports it's fantastic – you don't have to get on the courtesy bus late at night back to the car park with all the luggage. Usually you've been away for a week and can't remember where you've parked."

"Most of the time, airport valet parking has been the dream. Yes, the car comes back a bit dirty but I don't care."

"If I spend £2k on a holiday the additional cost of valet parking doesn't seem much. But it's a one-off experience… a treat rather than something you'd do every day."

"If it takes away the stress I'd be willing to pay for it. Traffic is terrible in Guildford, and if I was a car commuter I wouldn't hesitate to pay a bit extra if it made life easier."

Most concerns about valet parking were raised by those who had never used it. There were worries about:

- It being very expensive
- It being difficult/time-consuming to get the car returned
- Theft or damage to the vehicle

- The vehicle being driven places other than to be parked

"If there's damage to the car then it will be difficult to prove it happened under their watch – they won't take responsibility. I don't want to pay for the extra insurance."

"It fills me with dread, I don't want to give my car keys to anybody. What if they rent it out while I'm away?"

One person felt valet parking was an unnecessary luxury since he was able to park the vehicle himself.

"I don't even let my mum do the parking. It's my car, I'm driving it. I can find a space for myself, I don't really need someone to do it for me."

"I'd have to remove any valuables in the car in case it was stolen, and I don't have the patience for that."

5.2 Autonomous Valet Parking

5.2.1 Benefits

Upon learning about the AVP parking solution, reactions were mixed. Some of the benefits people could see were that it would:

- Reduce parking related stress
- Save time
- Free up space in car parks as vehicles can park closer together
- Make parking easier at e.g. hospitals, train stations and airports where there is often a rush to be somewhere
- Potentially be better for the environment, e.g. if it reduced congestion or if the AVP vehicle was also electric
- Be more trustworthy than a human VP service, lowering risks of:
    - Theft
    - Car being used for purposes other than parking
    - (To some) Damage

"I would feel more confident about the safety of my car if [the VP service] was not dealt with by a human"

"It would have massive benefits. No anxiety, no stress, no anger – you just have to think of where you are going. Not having to think about where you left the car, or having to drive around 15 minutes looking for a space or allocating time to park. As long as you know it's safe and secure, it's less stress."

"I think it is fantastic, I wouldn't have to worry about anything."

"A robot can't steal the car. I assume it is also less likely to damage the car. If the valet person is in a hurry for example, they're more likely to make mistakes."

"It would save time because you wouldn't have to do the drive around looking for a space. But the biggest benefit wouldn't necessarily be time saving but stress saving."

5.2.2 Worries

Some of the worries and concerns people raised about AVP were that:

- It would be an exclusive service, e.g. only available in high-end vehicles
- The technology wouldn't be mature enough when it reaches the market
- Driver parking skills would deteriorate
- The technology could be hacked
- Liability in case of incident
- Forgetting something/someone in the vehicle / Insufficient time to offload the vehicle before it drives off
- It would not be possible to return the vehicle due to:
    - Network outages
    - Lost/Damaged/Stolen mobile phone

"There are issues with maps and sensors all the time, I don't know how long it would take for the tech to be mature enough. I wouldn't want to be the guinea pig."

"The whole thing is freaking me out, my anxiety levels are sky high. If suddenly everything goes down, what do you do, how do you get your car back?"

"One of the issues I can think of, having kids, getting them out of the car when they were young, one of them always forgot something and we'd have to go back to the car. The car goes off and your kid goes 'I want my toy bear.' Then what do you have to do? You'll have to recall the car, it'll be an absolute nightmare."

"How long do you have to get out of your car before it drives off? What if you forget to take your kid out of the car and it drives off: 'bye see you later'? I would rather get complete road rage and have to wait four hours to find a parking space."

5.2.3 Uncertainties

Participants raised plenty of questions around how an AVP service would work and what the effects would be, for instance around:

- Accessing the vehicle while it is parked, e.g. for dropping things off
- How it will affect people who can't afford using AVP
- Who would insure AVP
- Charging if the vehicles are electric
- Whether it really would reduce congestion and queues or whether the time-saving effect would be lost once there is mass uptake

"I don't know how you can gauge the efficiency of it. Not everybody is capable to get out of their cars in a certain amount of time, but if you increase the time limit then there's going to be queues again."

"The time-saving would depend on how long you have to wait to get to the drop-off zone. Would there be a stretched-out drop-off zone so many people can get out at the same time?"

"I'm never going to afford using a service like this… What will be the knock-on effect on the car parks we have now, for the rest of us?"

"I am assuming that these vehicles will be electric… how would they deal with charging? Contactless charging freaks me out."

"Why would anyone insure something that's out of the driver's hand? The liability would be difficult - would it go back to the car manufacturer?"

"My wife usually wants to go back to the car to drop things off – where could you store things while the vehicle is away and parked? Could there be lockers by the drop-off/pick up zone?"

5.2.4 Requirements

Safety, security and affordability came up as some of the key requirements that had to be met for participants to consider using AVP.

"I would have to be certain that no-one can break into the car and steal things or drive away with it. That it is locked at all times, and that it sends me updates if something were to happen. Perhaps it should be linked to the phone or face recognition, so no-one but you can operate it."

"If my phone broke or got nicked, I would have to know that I can still get my car back."

"If the prices came down to a reasonable level and it was more available, I think it would be a great solution."

Being covered in case of an accident was another requirement raised by participants.

"I would need to know that I am covered insurance-wise if something goes wrong."

There was much discussion around how AVP would impact on congestion and queues inside car parks, with some believing that it would just shift congestion to the drop-off and pick-up zones. If that was the case, some felt it would zero out the benefits of using AVP.

"The drop-off zone can't be congested, otherwise there wouldn't be a point."

5.2.5 AVP zone

When asked where they would prefer the vehicle to park in the car park, many felt an AVP only zone would be the ideal as it was thought to be safer and more secure.

"I wouldn't want pedestrians to be able to access the AVP parking area – there'd be no other drivers there so it would be easier to break into the car."

"I'd prefer keeping them segregated, there are some horrible people who might see a driverless car and would think to damage it or steal it. It would be more secure if it went on a different route, using a different entrance and different section."

"I would expect it to be exclusive to automated cars. I wouldn't want it to meet my 83-year-old mother driving her Micra in there."

At the same time, many also pointed out that this would be unrealistic before AVP was offered on a mass scale.

"If you have mixed use, it will very difficult to get that efficiency benefit because humans will be parking like humans. You also have to consider the variable of human parking accidents; people are riskier. Perhaps you could two-tier it – multi-risk areas with mixed parking, and exclusive low risk areas."

Some felt it wouldn't make a difference where the vehicle parked, as it would be out of sight and mind.

"If you're not going to see it, you don't care. As long as it's not going to get hit."

5.2.6 Information needs

When participants were asked about what information updates they would like to get while the vehicle was away parking, most participants appeared to want frequent and detailed updates, such as:

- Access to live CCTV footage
- Notifications when the vehicle is parked and where it is parked
- Notifications if the vehicle moves
- Information about the status of the vehicle, e.g. about fuel levels or tyre pressure

"Perhaps it could give you information about anything running low in the vehicle, such as fuel levels or tyre pressure. It could also tell you if anything is wrong in your car… those things would be good to know, and if it would give you suggestions of where close by places to fix things are it would benefit local companies."

"I would like to have access to CCTV of the car so I can check that it's still there."

"It would be great if it lets you know where the car is parked. My iPhone does that already, and I'd imagine it would do something similar."

By contrast, some participants did not think they would need any updates while they were away from the vehicle.

"I'm assuming that when you leave it at the drop-off zone, it locks itself and drives off – you wouldn't need to know what happens after that."

5.2.7 Payments

Participants felt paying for parking would be much easier with AVP, as the assumption was that it would be done in advance or that the vehicle would check itself in and out, with payments being automatically drawn from an account linked to the AVP service.

"Payments would have to be done in advance, on your phone. You could just phone up and they've got all your details."

"If your car was already registered, you wouldn't have to do anything – you'd just have to show up at the car park, then check your bank account later."

"It would be easy… no ticket machines and no walking to the machine to get your ticket, or walking back to your car to stick the ticket on it."

5.2.8 Willingness to pay

Most participants thought the added convenience of AVP should come at an extra cost, as long as it was more efficient than manual parking.

"You do expect to pay more, similar to valet parking."

"As long as it's more efficient I would be willing to pay a bit extra. If it's not working, then you'd expect to pay less."

"I'd be willing to pay but it depends on how much benefits against the cost. If there's only one car park in town that's using it, then probably not."

"You do expect to pay extra as it is worth more."

"If it's optional, it's great. I find parking annoying, and I'd quite happily pay more avoid it."

5.3 Summary of Focus Group Findings

The focus group interviews explored drivers' experience of parking and valet parking, as well as their attitudes toward AVP. Some key findings and observations are:

- In both groups, there were individuals at both extremes of the scale in terms of likelihood to use AVP. Some would never consider it, either because they felt parking was easy, because it seemed expensive, or because of what appeared like a general scepticism against new technology. Others had a very positive outlook on this new technology, saw plenty of benefits, and expressed very few concerns or worries. Most participants, however, tended to be cautious about deciding whether they would use it or not, as this would be conditional on the technology being e.g. affordable, more convenient and efficient, and safe and secure. This goes in line with the survey results, where 21% of respondents would like to have AVP now, 40% agreeing that it is a good idea but they would need to understand more, and 19% stating that they would be unlikely to ever want to use it.
- The parking pain points that participants raised and that could potentially be addressed by AVP were:
    - Provided AVP involves automatic, account-based ticket payment and check in/out of vehicle, most reported payment related pain-points would be resolved (e.g. ticket machine issues, having to queue for ticket, advance payment with no refunds, complicated means of registering vehicle to receive ticket, etc)
    - AVP would remove most pain-points relating to the layout and navigation of the car park (e.g. poor access, narrow bays, poor visibility, poor signage, difficulties findings available spaces), as these occur during parts of the parking routine when the AVP service will have taken over, i.e. driving through the car park, finding a space, and manoeuvring into a space
    - If AVP will mean users spend less time in the car park overall, some pains relating to the condition of the car park (e.g. poor lighting, lack of cleanliness) may be reduced
    - AVP may make travelling with children, luggage or dependents easier
    - AVP may remove some pains relating to the interaction with other users of the car park (e.g. 'space stealing,' aggressive/stressed drivers, people holding others up), although in a mixed-use scenario users may still worry that their vehicle is put at risk by other drivers
    - Depending on how crowds and queues are managed at the drop-off and pick-up zone, AVP may remove the pain of overcrowding and congestion in the car park

- Compared to manual parking, participants particularly emphasised the benefits of stress and time savings
- Compared to human valet parking, some participants felt AVP would be safer and more secure. Others felt it would be easier to trust a human operating their vehicle
- Participants asked plenty of questions around how the AVP service would work in practice. These uncertainties will likely have to be addressed for the solution to appeal to the wider population
- In particular, end-users will need reassurance that:
    - Their vehicle is insured in case of an accident
    - They have sufficient time to exit the vehicle at the drop-off zone, particularly if travelling with children or luggage
    - They can get their vehicle back in case the technology fails, e.g. during a network outage or if their mobile phone is lost or breaks
    - There is enough protection in place to ensure the vehicle won't be hacked and stolen
    - The vehicle will not be driven or parked in areas where there is an increased (perceived or actual) risk of it being damaged

6. Conclusions and Recommendations

This report has summarised the customer and user research conducted as part of the Autonomous Valet Parking project. The aim of the research was to, in relation to AVP, explore customer and user needs and attitudes, as well as to explore the impact of AVP. To achieve this, a literature review, stakeholder interviews, a survey, and two focus groups were conducted.

Below, the key findings are summarised **into the three overarching themes that have guided the research**. Thereafter, a list of recommendations for AVP solutions is presented.

6.1 Key Findings

6.1.1 User attitudes and needs

Parking is one of the biggest pain points experienced by drivers. Previous research shows that 44% of drivers feel parking is stressful (Opinium 2016). For indoor car parking, our survey showed that the following aspects were particularly problematic:

- **Finding a space in the car park.** Only 33% of respondents to our survey felt this was easy. In our focus group interviews, participants explained that some of the issues with finding a space are that the car park is difficult to navigate (so that, even if drivers are aware there are available parking spaces, it is difficult to find them) or that available spaces are hard to park in due to the size of the space, pillars, or adjacent vehicles being parked poorly.
- **Driving through the car park.** Only 50% of respondents to the survey felt this was easy. Focus group participants pointed to car park layout, pillars and bollards, and poor signage and markings as key factors impacting this.
- **Paying for parking.** 52% of our survey respondents felt this was easy. Focus group participants offered a host of reasons why parking is often problematic, such as broken ticket machines, queues, poor user design, and machines that do not accept multiple types of payment method (e.g. only cash or card).
- **Finding vehicle upon return.** 53% of respondents to the survey felt this was easy. Focus group participants did not touch upon this topic, however likely factors impacting on the ease of finding the parked vehicle are car park layout and signage.
- Not everyone felt the same way about the pains of parking. According to our survey, indoor car parking was overall **more painful to people aged between 17-29** than others.

Drivers found that parking was the most popular scenario for the car taking control, more so than driving on motorways or in urban areas. Over half of drivers either want AVP now or were receptive to the concept and willing to know more:

- 21% of the respondents to our survey would like to have AVP now. Men were more likely than women (23% compared to 18% of women), and respondents aged 17-29 more likely than older respondents (28% compared to e.g. 9% of those aged 70+), to want AVP now.
- 40% of survey respondents thought it is a good idea but would need to know more before trying. Some of the questions our focus group participants wanted to know more about before trying were around insurance, ability to access the vehicle while it's parked, and cost.

Like any valet parking service, an AVP service would alleviate the parking related pain points outlined above. In our survey and focus groups, the main benefits drivers could identify were that it would:

- **Make parking less stressful.** Of those of our survey respondents who would consider using AVP, 58% thought it would have stress-reducing benefits. Our focus group participants discussed how an AVP service would take away the stress associated with finding parking, queuing to get into the car park, or manoeuvring into a space.
- **Make parking with children easier.** 52% of survey respondents who would consider using AVP agreed with this statement. Apart from making parking with children easier, focus group participants also discussed the benefits AVP could have when travelling with a lot of luggage or with elderly or disabled passengers.

The main concerns end users had about AVP were that:

- **The vehicle would be damaged during the auto-parking operation.** This was a concern to 48% of survey respondents who would consider using AVP. It was also discussed frequently by focus group participants, many of whom said they would only use the service if they were confident that the risk of damage to their vehicle was low or non-existent. In conjunction with this, focus group participants raised questions around who would be liable in case of accidents or incidents.
- **It would take long to retrieve the car after it has been parked.** 43% of survey respondents who would consider using AVP stated this as a concern. Focus group participants were worried that, in a high-uptake scenario, the queues around the pick-up zones would negate any time-saving benefits of AVP. They were also concerned about what would be the effect on the ability to retrieve the vehicle in the case of lost/broken mobile phones or during network outages.
- Attitudes to, and perceived benefits of, AVP varied across different groups:
    - Younger people, and people who currently own a vehicle with automatic parking functionality, were more open to trying AVP and to pay extra for the service.

6.1.2 Stakeholder needs

Our stakeholder interviews suggest that, to get AVP buy-in from car park operators:

- The solution must not require costly infrastructure investments, in particular if evidence that the cost will be recovered within the operator's lease period is lacking
- Uncertainties around liability and insurance must be resolved
- Offering AVP must not lead to underutilisation of space (e.g. if parking slots/areas of the car park is reserved for AVP at the same time as demand for this service is low)

6.1.3 Impact

Our research could not satisfactorily confirm the degree of environmental and economic impact AVP is likely to have. It is clear that congestion caused by parking search contributes to pollution and emission levels, however more research is needed to understand the degree to which AVP would reduce parking related emissions, especially in relation to indoor car parks.

Apart from removing parking related pain points, one of the social benefits of AVP would be to improve accessibility for individuals with e.g. disability and make parking more inclusive.

6.2 Recommendations

Our findings suggest that an AVP service is more likely to be easily accepted by those who already use driver assistance technologies, are aged under 30, are male and have used valet parking previously. At the same time, the benefits of not parking (in particular, the benefit of reduced stress) would be more valued by female drivers.

- In order to market the service to female drivers, these benefits would need to be balanced against lower trust in autonomous technology

Likely early adopter of AVP	Likely to benefit the most from AVP
Aged under 30 Men Have used valet parking Experience of driver assistance technologies	Women Young drivers and older drivers Drivers with dependents

FIGURE 6.1: Likely adopters vs likely to benefit

Shopping is by far the most common activity being carried out when indoor car parks are used in UK (70%). There are also opportunities to approach indoor car parks for leisure activities, at hospitals and at stadia or large event venues.

- Further research into how an AVP service could enhance the experience of undertaking these activities should be taken – for example if shopping could be loaded into car boots without shoppers having to carry it back to the car park
- All these activities are unlikely to be regular daily occurrences, and many will be infrequent, 'one-off' or special occasions. Therefore, aggregated time saving may not be key for the value proposition for AVP

Opinion is split about how the car should 'behave' once it goes into autonomous mode. End-users' fear of damage to the car probably dictates that complete segregation from other vehicles is preferred. By contrast, findings from our stakeholder interviews suggest that car park operators will be reluctant to offer a service requiring costly investments on their behalf, which could be the case if AVP cars are segregated from other vehicles in the car park.

- Further trials and research with both end-users and stakeholders are required. Concerns about vehicle damage need to be balanced against cost and practicality considerations

Many drivers are not willing to pay extra in car parks to use AVP spaces so any additional cost to the car park owners and operators to set up and manage an AVP service may not be absorbed by car park users. Our interview findings suggest that this could pose a serious barrier to buy-in from car park operators.

- The commercial arrangements between authorities, OEMs and car parks will need careful consideration

The interviewed stakeholders expressed uncertainty about what would be the motivation for car park operators to offer AVP in their car parks.

Further research and engagement with stakeholders are needed, in particular to understand:

- How car park operators can recover costs incurred from e.g. infrastructure upgrades, an initial period of low uptake of AVP and hence underused capacity, and any potential economic loss from more accurate parking pricing (assuming automated payment of tickets)
- How ticketing and payment would work
- How liability and insurance would be dealt with

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