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Decision-Making in the UK Transport System

Future of Mobility: Evidence Review

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Decision-Making in the UK Transport System

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Executive Summary

Mobility affords a range of societal and economic benefits, but current transport systems also suffer from a number of intractable problems. At the same time, urbanisation, changing demographics (e.g. ageing population), a growing population, delayed car ownership, electrification, increasing connectivity, and automation are likely to impact on mobility systems with significant changes over the next 20 years and beyond. These and other developments will see disruptive innovations and socio-technical transitions within mobility systems that will have profound impacts on society, economy and the environment.

This report reviews the evidence on consumer decision-making in relation to current and emerging transport technologies and modes, including electric and autonomous vehicles (EVs, AVs), and mobility as a service (MAAS). We used multiple sources to compile this review, including bibliographic literature searches, a call for evidence, and interviews with industry and academic representatives. The report examines (a) trends and demographic variation in travel behaviour (b) factors influencing travel behaviours (c) attitudes and behaviour in respect of EVs, AVs and MAAS, and (d) projected changes in travel behaviours and decision-making up to 2040. As such, it integrates insights from psychological literatures on decision-making and behaviour, with perspectives on broader socio-technical transitions, as well as expert views to triangulate and extend the published research on these emerging trends.

Trends and demographic variation: UK transport has become increasingly car-centred, with most trips taken by car. There is growing car dependence or ‘lock-in’, due both to urban form built around cars and the accumulating cultural and symbolic value of cars. This ‘lock-in’ limits individual choice and constrains transport decision-making. There are, however, indications that this car dependence may be weakening slightly, at least among younger demographics (so-called ‘peak car’) with growing evidence to suggest that there is sustained change in travel behaviour since the early 1990s among younger people which is continuing throughout their life. Observed behaviours such as delayed onset of driving, the reduction in demand once driving is taken up and securing of full-time employment all mark shifts in car ownership and use among this cohort. This cohort effect is predicted to extend into subsequent cohorts. Other demographic factors influence travel choices: larger households are more likely to own cars; higher income is related to car ownership and more travel; men travel and drive more than women (though this difference is narrowing); and car use declines and bus use increases after retirement.

Factors influencing travel behaviours: Travel behaviour is influenced by: (a) self-reported motivational factors (autonomy, affordability, satisfaction), (b) unconscious factors (habit, social norms, symbolism), and (c) structural factors, including socio-demographic factors (income, occupation, parental status, etc.), the built environment (e.g. urban design), transport service provision, and perception of these structural factors. Critically, the evidence shows that transport behaviour is often driven or constrained by external influences (e.g. design of the built environment). At the same time, these constraints are experienced subjectively, such that some individuals may be prepared to walk or cycle, for example, where others would not.

Decision-making in respect of EVs, AVs and MAAS: While technophiles and those with green values are willing to adopt EVs, many individuals perceive the current generation of EVs as a ‘work in progress’ and too costly, despite being cleaner than conventional vehicles. Other barriers to adoption include limited rapid-charging infrastructure, leading to ‘range anxiety’. Given the importance of familiarity for the adoption of new (vehicle) technologies, social networks may be key to EV promotion. Less is known about how the public will respond to AVs, though the evidence suggests considerable heterogeneity: while some (e.g. technophiles) are enthusiastic about the safety benefits and potential to free up travel time, others are less willing to trust machine drivers. AVs may also offer more mobility to those currently unable to drive (e.g. the elderly or people with disabilities). MAAS options, including car sharing, appeal to certain groups by reducing the ‘burden of ownership’, and being cheaper and more sociable. Trust in service providers and other users is an important precondition for acceptance, though. Some perceive car or bike sharing as inconvenient, and may feel that owning a car is important for status or identity. Barriers to bike sharing include safety concerns and distance from bike station.

Projected changes in travel decision-making up to 2040: We examine the impact of megatrends (e.g. population growth, ageing population, electrification, urbanisation) on the adoption of EVs, AVs, MAAS and alternatives to travel (e.g. telecommuting). We conceptualise these innovations as ‘niches’, and identify EVs as most compatible with the current mobility regime (dominated by personal mobility and car-based urban form), albeit still requiring change in infrastructure and lower costs to support widespread EV diffusion. AVs and particularly MAAS comprise more radical disruptions to the mobility regime, albeit supported by certain landscape changes, such as increasing vehicle automation and decline in car ownership among younger groups.

We conclude with policy implications and a research agenda to address gaps in the literature. These gaps include understanding willingness to share under different scenarios; examining how ‘peak car’ relates to life stage; exploring how people will use AVs and the consequences of AV diffusion for society; and ensuring that transport models and forecasts are behaviourally realistic.

Contents

1 Introduction

Mobility affords a range of societal and economic benefits, from access to services and employment to economic development and cultural exchange. But current transport systems also suffer from a number of intractable problems, including congestion, emissions of greenhouse gases (GHGs) and local air pollutants, noise, accidents, depletion of resources, and inaccessibility of amenities and services (SUMMA, 2005). At the same time, several megatrends[1] – including urbanisation, ageing population, vehicle electrification, increasing connectivity, and automation – are likely to impact on mobility systems, with significant changes over the next 20 years or so. These and other developments will see disruptive innovations and socio-technical transitions within mobility systems that will have profound impacts on society, the economy and the environment.

The aim of this review is to examine consumer decision-making in relation to current and emerging transport technologies and modes, including electric and autonomous vehicles, and 'mobility as a service'.[2] These emerging innovations are likely to have a revolutionary impact within the next 20 years and a more evolutionary one beyond. The review was commissioned by the Government Office of Science's Foresight Future of Mobility project, which aims to explore potential opportunities afforded by the transport system of the future, and implications for Government and society.

This evidence review summarises, in an accessible way, the most relevant and robust evidence about decision-making in relation to transport, emphasising key findings, gaps in the evidence base, and implications for government. The focus is on UK research, but international comparisons and good practice are incorporated where relevant. A mixed-methods approach to data collection was adopted, comprising bibliographic literature searches, a call for evidence, and stakeholder interviews (see Section 5 for details). While there is an extensive literature on transport-decision making in relation to established transport modes, there is comparatively less on transport modes that have yet to be widely adopted (such as electric vehicles and shared services). As such, to be able to consider the future of mobility in the UK, both the transport decision-making literature and public acceptance of future transport modes were reviewed. Reflecting the call specification and weight of literature, domestic, land-based transport modes for non-commercial use were focused on.

[1] An important shift in the progress of a society or of any other particular field or activity; any major movement (Oxford English Dictionary).

[2] A number of definitions exist for 'mobility as a service'. A 'weak' definition is 'the integration of various forms of transport services into a single mobility service accessible on demand' (https://maas-alliance.eu). Stronger definitions emphasise the contractual nature of a package of services provided by different entities but secured through a specific 'application'. Hence, 'Mobility as a Service brings every kind of transport together into a single intuitive mobile app. It seamlessly combines transport options from different providers, handling everything from travel planning to payments. Whether you prefer to buy journeys on demand or subscribe to an affordable monthly package, MaaS manages your travel needs in the smartest way possible' (http://maas.global/what-is-mobility-as-a-service-maas/).

The following section outlines the results of our research, drawing a broad distinction between historical and current travel behaviour and decision-making (Sections 2.1 and 2.2) and perceptions and decision-making in relation to emerging transport technologies and modes (Section 2.3), while also discussing the relationships between the two areas and the diverse factors influencing them. We also draw tentative conclusions about possible changes in decision-making and preferences over the coming years to 2040 (Section 2.4), and outline implications and suggestions for present-day decision-making and future research directions (Section 3).

2 Results

2.1 Temporal variations and demographic differences

2.1.1 Car dependence and 'lock-in'

Some key trends in travel mode use over the past 65 years are shown in Figure 1. Broadly, since 1950, UK transport has become car-centred:

1. The majority of travel is undertaken by car (around 92% of distance travelled in the UK, 64% of trips in 2015);

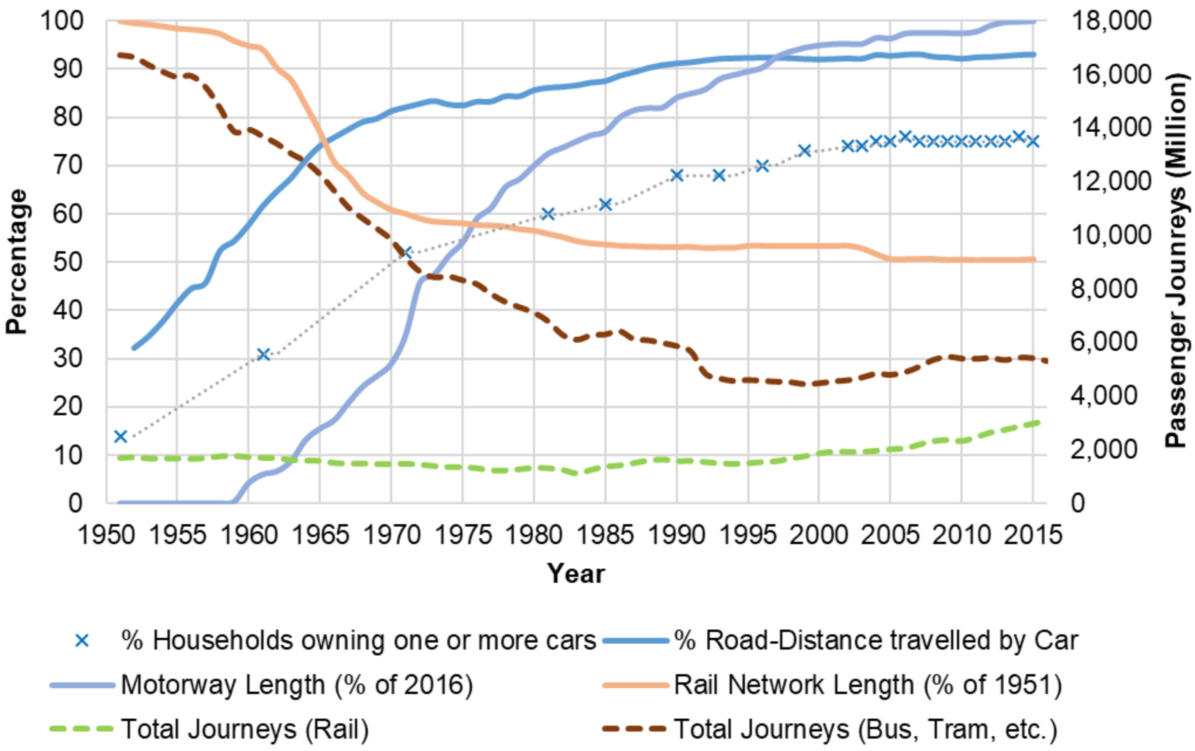
2. cycling has declined substantially (from 13% of distance travelled in 1952 to less than 1%); and

3. while rail travel has doubled since 1994, it remains a minority mode as a share of distance (10% of distance travelled in the UK in 2015).

Similarly, individuals have increasingly come to use a smaller set of travel modes over the past 20 years (Heinen & Mattioli, 2017). Theorists have identified, alongside these trends, an increasing necessity for cars in order to travel (for both work and leisure), as well as accumulating cultural and symbolic value of cars (Urry, 2004; Whitmarsh & Köhler, 2010; Kanger & Schot, 2016).

One important element is 'lock-in' (Cowen & Hulten, 1996; Marletto, 2011), where historical events lead to irreversible trends in adoption of one technology or system over another, irrespective of which technology or system is more useful. Part of the 'lock-in' of car use is that, with the ability to travel quickly, destinations no longer need be close together, and so location options for a particular type of activity, such as employment or shopping, are selected further from residences, leading to greater car use (Metz, 2008). Motorway construction facilitated this process (Spence & Linneker, 1994). Psychologically, the predominance of cars corresponds to another important element, perceived car-dependence: that 'many people find it difficult or impossible to envisage life not built around their car' (Goodwin et al., 1991, pp. 37–40; see also Lucas, 2009). While car dependence can be understood in different ways (Lucas, 2009), it has descriptive value in referring to different aspects of the psychology of car ownership and use, elaborated upon in this review: the autonomy that individuals aspire to through car ownership, as well as the symbolic/emotional value of cars and the development of car use habits. Critically, the concept also highlights the limits to individual choice and the inevitable constraints on transport decision-making that are evidenced in the travel behaviour literature.

Figure 1: Long run trends in transport (1950–2015) source: DfT, 2016



2.1.2 'Peak car'

There are, however, indications that the UK's car dependence may be weakening slightly. In recent years, researchers have noted an apparent slowing, or slight decline, in car ownership and use in developed countries, including the UK. This phenomenon has been termed 'peak car' (Focas & Christidis, 2017). The explanations of 'peak car' trends remain unclear, but some researchers attribute changes to extensions of historical trends (e.g. fuel prices, real income, urbanisation and embedded car culture: e.g. Wells & Xenias, 2015; Bastian et al., 2016; Stapleton et al., 2017) suggestive of a shift away from dependence (e.g. Metz, 2012; Lyons, 2014). For instance, one trend cited as related to 'peak car' is that, on average, younger people are less often motorists compared to previous generations (Kuhnimhof et al., 2012; Tilley & Houston, 2016). In the UK, since the 1990s, 40–69-year-olds have maintained a consistent level of driving licence holding, of around 80%, whereas, since peaking in the 1990s, licence holding of 16–19 and 20–29-year-olds has declined: for 16–19-year-olds from 48% to 31%, and for 20–29-year-olds from 75% to 66% (Department for Transport, 2016).

Crucially, what remains unclear is to what extent this peak is an age effect, due to the acquisition of driving licences being delayed, in which case the significance of the change is singular, and possibly already fully evolved, or whether it is a cohort effect, with the lower level of licence holding being maintained across the lifespan. In the latter case, the significance will in turn depend on the behaviour of future cohorts of 16–19-year-olds and 20–29-year-olds. A recent evidence review and secondary data analysis of the driving behaviour of 17–29-year-olds in the UK concluded that early life transport behaviour is sustained (e.g. lower car use in this age range during the 1990s is maintained in the present day) and that those who start to drive later in life will subsequently drive less. Of those who are presently between 17 and 29 years old, those who secure stable, full-time employment will be more likely to own and drive cars (compared to those who do not). The authors anticipate that the travel behaviour of the next generation will be similar to those born in the 1980s and 1990s (Chatterjee et al., 2018).

2.1.3 Life-cycle changes

Research has shown that user transportation changes with life-cycle events (e.g. childbirth or relocation) that occur across the life course (Schoenduwe et al., 2015); in the UK, key events are associated with changes in travel mode choices (Clark et al., 2016a) and changes in car ownership (Clark et al., 2016b). With respect to these changes, Dargay and Hanly (2007) found that:

1. car ownership within households fluctuated, though households rarely relinquish car ownership altogether;

2. car ownership is associated with the number of adults (and children) in the household;

3. unemployment and retirement are associated with car ownership reductions; and

4. house and/or job changes often mark changes in car ownership – changes in both often mean that car ownership increases.

Car ownership also tends to show a positive relationship with both personal and household income, so that as income rises or falls, car ownership rises or falls. Clark et al. (2016b) found that cohabiting with a partner or having children increase the likelihood of becoming a car-owning household. Importantly, life events likely mark changes in circumstances that lead to changes in transport behaviour and car ownership through a process of re-evaluation (Clark et al., 2016). As such, it has also been hypothesised that disruptions in existing habits, brought about by life-cycle events (see Section 2.2.3), could facilitate travel behaviour changes (Verplanken et al., 2008).

2.1.4 Gender differences in transport decision-making

Several gendered differences exist in travel use and choices. Traditionally, commuting patterns differ between men and women, both in metrics and form (Goodwin et al., 1991; see also Boarnet & Hsu, 2015; Tilley & Houston, 2016). This can be explained by traditional differences in social roles between women and men in the UK: breadwinner/ caregiver roles are divided within the household (Dobbs, 2007). This is illustrated by differences in trip purpose(s) in the UK. In 2016, men made, on average, 42 more commuting trips (1,299 km) and 12 more business trips (996 km) than women. Women made, on average, 42 more school runs (98 km) and

31 more shopping trips (248 km) than men (Department for Transport, 2016). Similarly, men travelled further than women by 2,154 km, which is about 33% of the average annual distance (Department for Transport, 2016).

Figure 2a: Travel mode choices by gender (2016) source: DfT, 2016

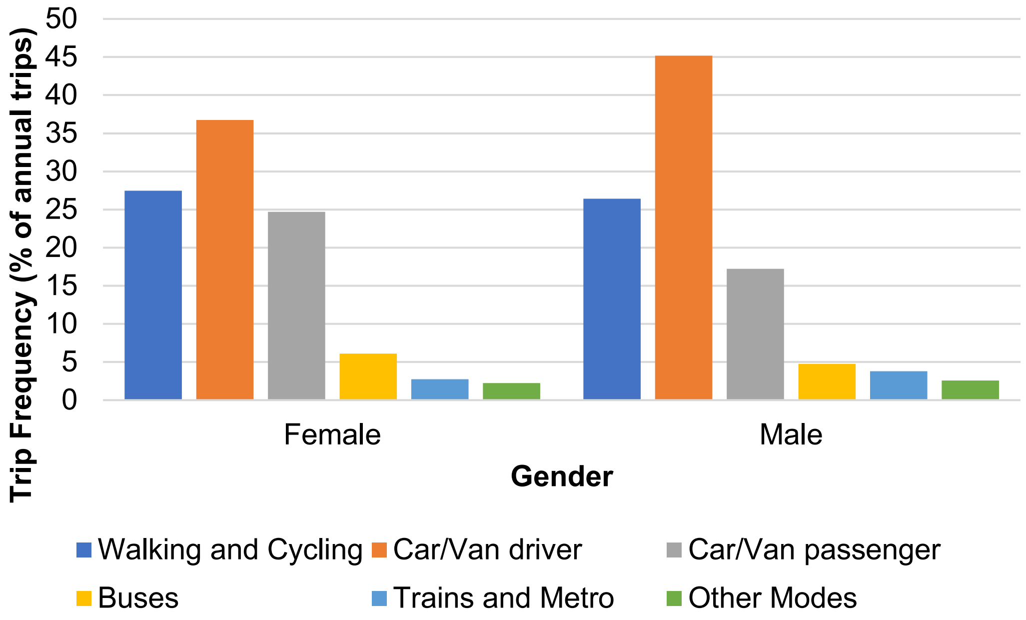
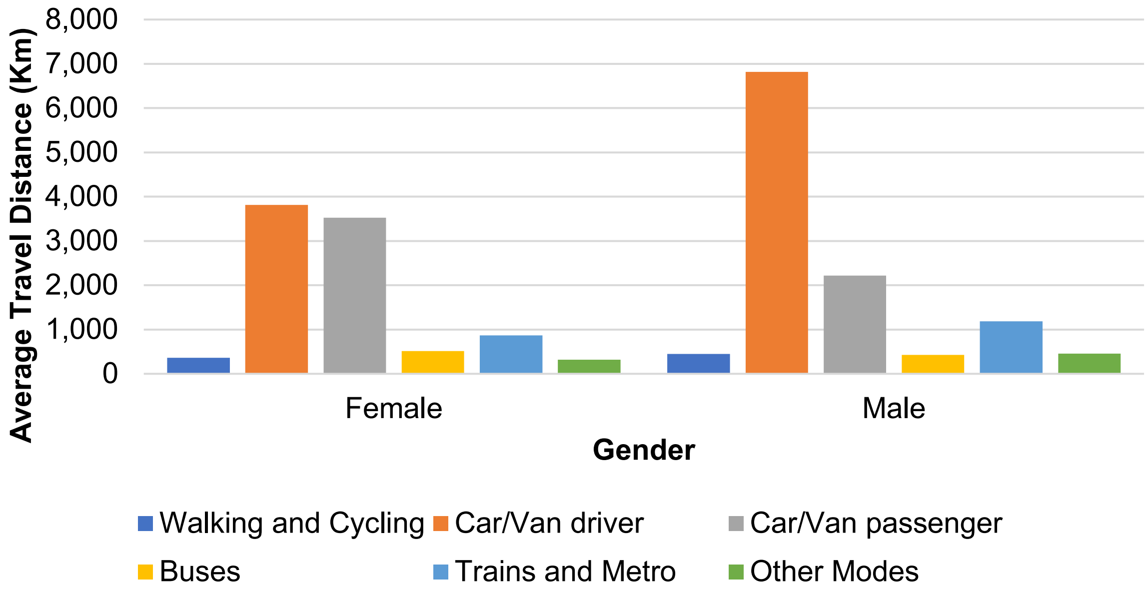


Figure 2b: Travel mode distances by gender (2016) source: DfT, 2016



This difference has been attributed to greater car access, and still a degree of homogeneity of household roles, among men (Tilley & Houston, 2016). Indeed, in 2016, more men than women had driving licences (80% to 67%) and, in households with at least one car, men are more often the 'main driver' (by 65% to 52%) and women are more often either the 'other driver' or a non-driver (by 38% to 20%;

Department for Transport, 2016). These trends are also reflected in car use (Figure 2). In 2016: (1) men drove cars more often (by 59 trips) and further (3,004 km, 56.8% of the average distance) than women, and (2) women were *driven* (as passengers) more often (by 82 trips) and further (by 1,300 km, 45.1% of the average) than men (Department for Transport, 2016).

However, while male and female travel patterns remain different, they are beginning to converge in several respects. Tilley and Houston (2016) used data from the English National Travel Survey to compare car use between men and women in different birth cohorts (generations) between 1995 and 2008. Importantly, women of 'generation Y' (born 1976–1985) and 'generation X' (born 1966–1975) increased, on average, their distance travelled by around 20 km a week over 10 years; male distance travelled in these cohorts did not change, on average. Kuhnimhof and colleagues (2002) observed similar trends in car use since 1975, and Heinen and Mattioli (2017) show that male and female modal variety has converged over the last 20 years, with car use becoming more dominant amongst women than it has been before. It is plausible that some of these trends reflect a growing gender equality in employment, but which has yet to fully occur for division of labour within the household (Kan et al., 2011).

Another gendered difference in travel is the fear of crime - women tend to experience a greater fear of crime when using public transport or walking (despite, or perhaps because, they are less likely to drive; Law, 1999; Lorenc et al., 2013; see also Cozens et al., 2003). Although women, in fact, already use local buses more than men, fear is likely to be a factor which deters use by both genders, and by implication, addressing these fears through means such as better design of public transport and walking environments could be an important element in encouraging their use (see Section 2.2.2).

2.1.5 Transport decision-making in an ageing society

The UK has an ageing society: 20% of the population are aged 65 or older, compared to 14% in 1976; life expectancy at birth (in 2015) had increased, since 1991, by 5.7 years, to 79.1 years, for males, and by four years, to 82.8 years, for females (ONS, 2017). This trend has inevitable implications for transport choices and usage. Rosenbloom (2010) considered some of the important implications for transport in the UK (see also Figure 3). Firstly, drivers are likely to continue to drive with increasing age: car use beyond the age of 60 continues to increase in the UK, with, in 2016, 60–69-year-olds making around 57 more car trips (driving 943 km further), and those over 70 years around 87 more car trips (driving 728 km further), than in 2002 (Department for Transport, 2016). The implication of this, given current transport systems, is that these generations will continue to drive for longer, with potential impacts upon traffic (including congestion), carbon emissions from transport, and road safety, as driving ability declines with age (e.g. Clarke et al., 2010).

Figure 3a: Travel mode choices by age group (2016) source: DfT, 2016

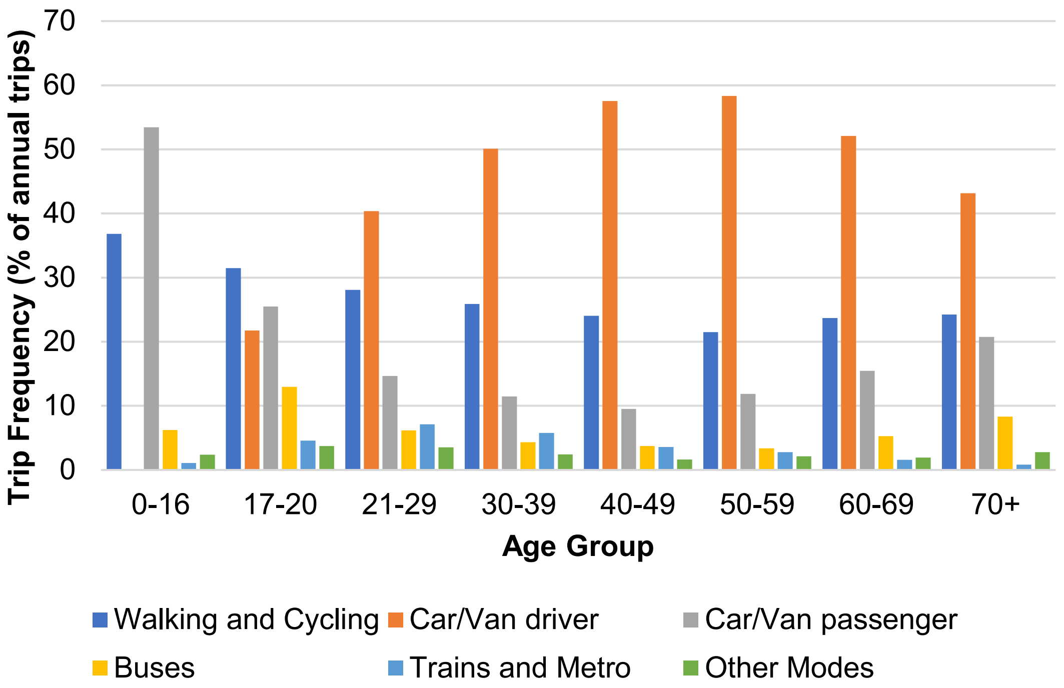
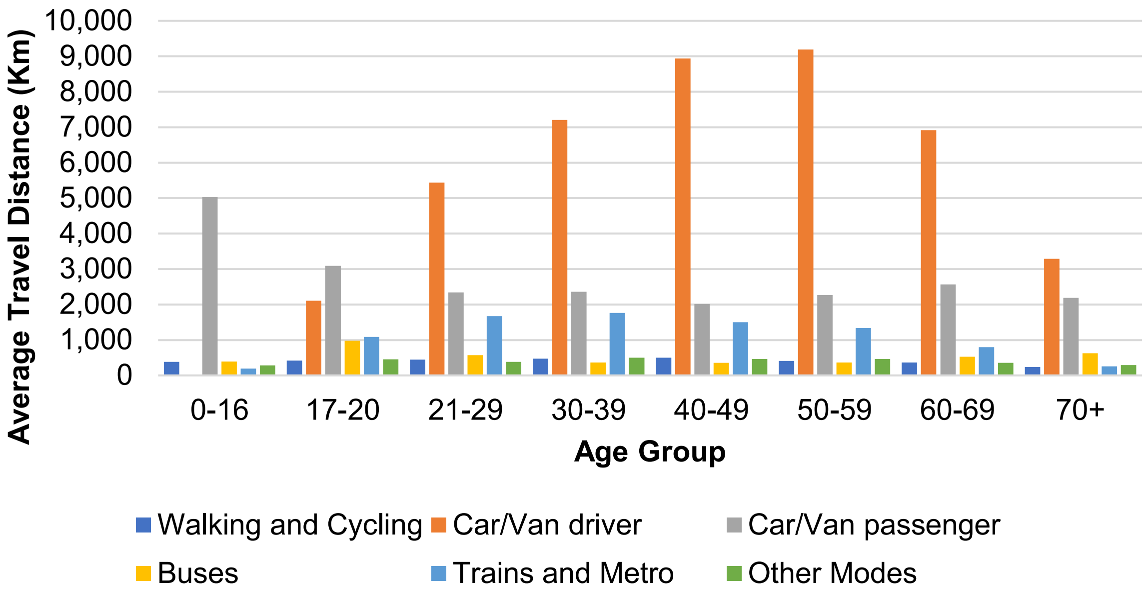


Figure 3b. Travel mode distances by age group (2016) source: DfT, 2016



Second, either a technological solution will enable older people to continue to drive safely into their later years, or they will have to forego driving while still having needs for travel, these perhaps being met by relatives (providing lifts), state provision (bus services) or pension/insurance provision (to pay for driving services) (Shergold et al., 2015). The process of adapting to later years spent without car access differs between individuals, but there are indications that certain factors, such as planning for this event, having a support network, and access to local amenities (probably through a bus service), can improve the quality of later life (Musselwhite & Shergold, 2013). However, older citizens are not distributed evenly across space, and due to both ageing in situ and retirement choices are overrepresented in rural areas, which creates an additional policy challenge in providing interventions that can ensure social inclusion in an affordable way (Shergold & Parkhurst, 2012).

2.1.6 Income inequality and transport poverty

'Transport poverty' refers to the affordability of transport costs (Mattioli et al., 2017, p. 95); although often the topic is approached through the related, although different, measure of 'income'.[3] Figure 4 shows differences in travel behaviour by income in 2016.[4] While the effect of income upon transport choices is considered in Section 2.2.2, it is useful to briefly outline the issue of transport poverty. When UK transport users are segmented (i.e., grouped into 'types' of traveller using cluster analysis), income is an important factor differentiating groups in society (Thornton et al., 2011; Prillwitz & Barr, 2011). Goodman (2013, p. 6) showed: (1) that walking and public transport were important transport modes for the socially deprived, whereas cycling was used by the deprived and affluent alike; (2) over a decade, affluent transport users had reduced their (collective) car use (by -4% for the most affluent 5%) and slightly increased their (collective) use of alternative modes (by +1% for the most affluent 5%). There is also some evidence that income discriminates between the variety of modes available, with those earning within the top 20% of income using, on average, 0.15 additional travel modes per week, while travel mode variety has declined for other income groups (Heinen & Mattioli, 2017, pp. 16, 18). Transport poverty is thought to be related to adverse social outcomes through limiting access to opportunities and social networks (Mattioli et al., 2017); however, further research is needed to fully understand these relationships and their mechanisms. Overall, these findings tend to indicate that while the poorest in society can be limited in their opportunities through a lack of affordable transport, those who can afford transport have the means to use a wider variety of transport to access destinations.

[3] Different in particular because a household may be relatively wealthy by most reasonable assessments, perhaps due to accumulation of assets over many years, but have a relatively low current income, perhaps because the members are all receiving pensions.

[4] Other modes also include travel by taxi, which account for the disparity in distances with income in Figure 4b.

Figure 4a: Travel mode choices by real household income quintiles (2016) source: DfT, 2016

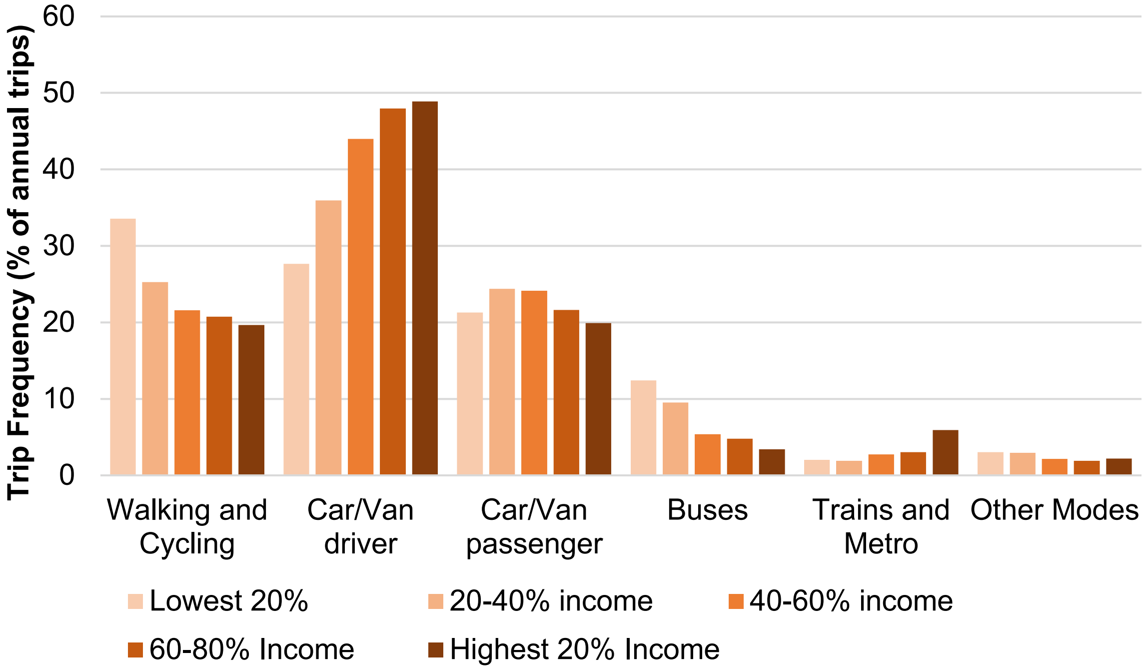
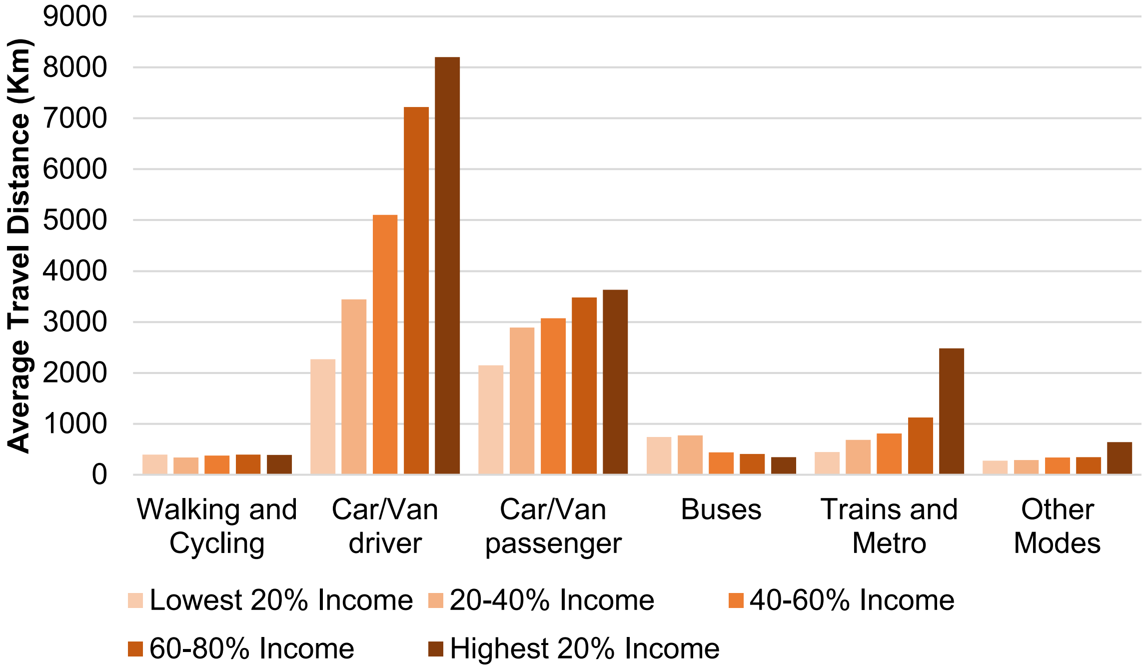


Figure 4b: Travel mode distances by real household income quintiles (2016) source: DfT, 2016



2.1.7 Summary

- Car use is predominant within the UK. Travellers in the UK are (and often perceive themselves to be) dependent upon their cars for their day-to-day travel needs.

- While recent trends indicate that car use could have reached its ‘peak’, with declining car use among younger generations, there is still insufficient evidence that such trends reflect a fundamental change in travel, rather than only a temporary fluctuation.

- As infrastructure and land-use choices have responded to the predominance of car use, different locations (jobs, shops, homes) have become more geographically dispersed, helping to ‘lock in’ car use as a means of access to destinations.

- ‘Transport poverty’ can arise to the extent that less affordable transport modes (e.g. driving and taking trains) have become necessary to gain access to new opportunities (e.g. for employment, social networks), or affordable transport modes (e.g. buses, walking) can no longer provide access to opportunities. Transport poverty could have consequences for equality of opportunities and social mobility.

- Demographically, the population of the UK is becoming older (we have an ageing society). As individuals live longer, they have continued to drive and use public transport. If this trend continues, there will be implications for transport demand and its associated impacts (traffic, emissions and road safety).

- Importantly, the uneven distribution of elderly/retired people across the country may lead to additional policy challenges in providing interventions which can ensure social inclusion in an affordable way.

- Innovations in driving technology may assist some ageing travellers (e.g. autonomous vehicle technology); however, others will rely on relatives (providing lifts), state provision (bus services) or pension/insurance provision (to pay for driving services).

- In the UK, women are less often motorists than men, but this gap has narrowed over the past 20 years. It is likely to continue to narrow, so long as society continues to increasingly value gender equality, in the workplace and in the household.

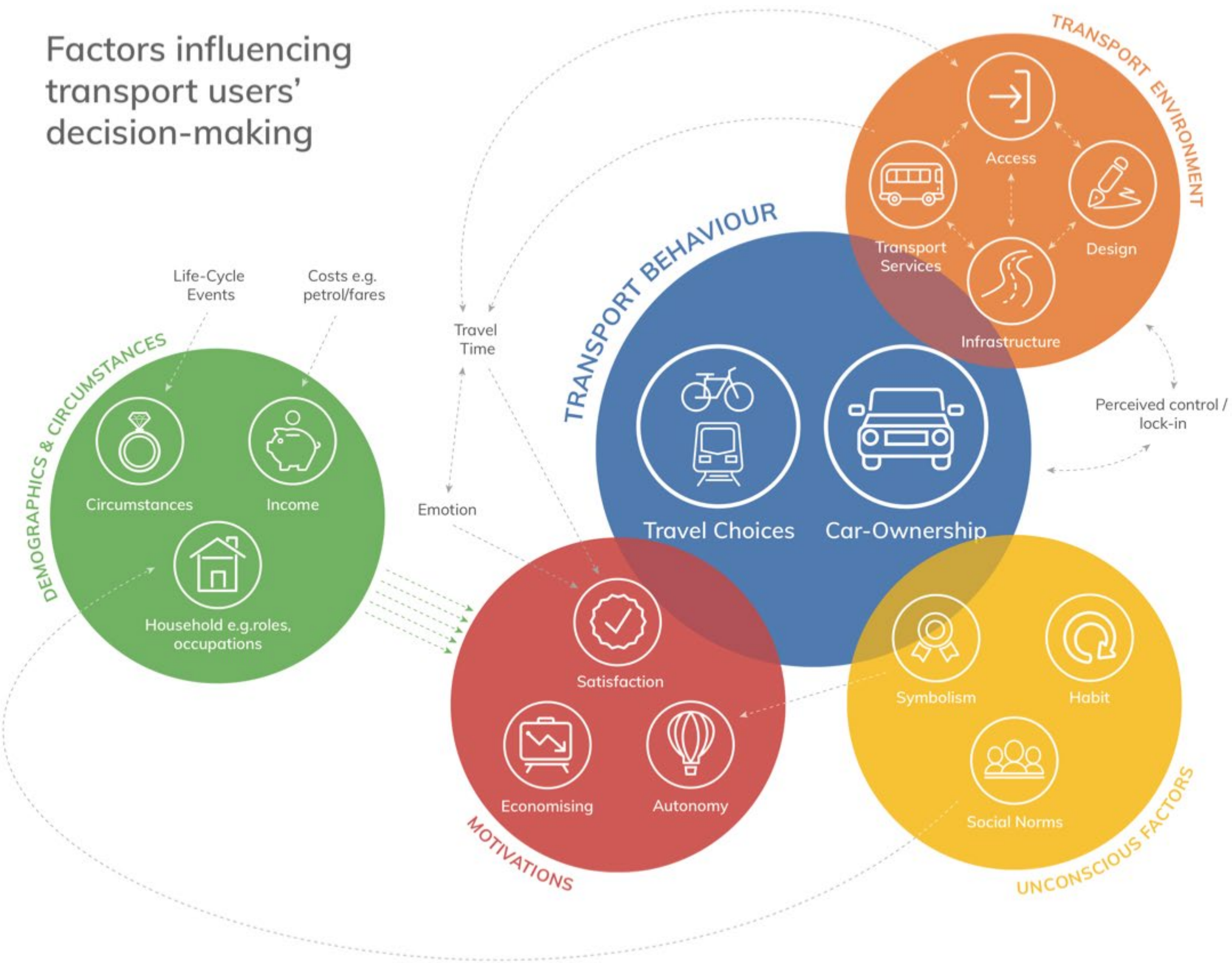
- However, this could also lead to increasing car use, and it may be useful to consider how gendered differences in transport perceptions (such as the fear of crime) may contribute preferences for car use over public transport or walking and cycling.

- Individual travel behaviour changes across an individual’s lifetime. These changes correspond to important life-cycle events (such as moving house, having children and employment changes). These events reflect the changing needs of individuals for travel as well as circumstantial opportunities for making lifestyle and transport behaviour changes.

2.2 Factors influencing transport users' decision-making

What shapes transport users' decisions? Of the factors that shape transport users' decisions, which are most important? We have broadly divided these factors into three overlapping categories. **Self-reported factors** are those that transport users themselves identify as most important in their decisions. **Structural factors** are those related to socio-demographic factors and to the transport system. Unconscious factors are psychological motivations that transport users are not fully aware of that influence their decisions. Less evidence is currently available concerning unconscious factors: they are difficult to assess and are less extensively studied by comparison to other factors. A summary of all three types of factor and their relationships is shown in Figure 5.

Figure 5: Main factors influencing transport users' decision-making



Note: 'Motivations' (red circle) encompass self-reported factors, while unconscious factors (yellow) are also shown to influence transport behaviour (blue), along with both physical (orange) and demographic (green) structural factors.

2.2.1 Self-reported factors

Autonomy

Human autonomy (freedom, control) is (ostensibly) an important motivation for car use and ownership. ‘Freedom’ is a common first answer when people are asked what the advantages of car use are for them (Hagman, 2003). This ‘freedom’ captures the access, flexibility, reliability and convenience that a car affords, as well as a more fundamental feeling of being in control of one’s journey (Gardner & Abraham, 2007; Mann & Abraham, 2006; Hiscock et al., 2002). Jensen (1999), surveying 788 transport users in Denmark, found that 79% of motorists (51% of non-motorists) agreed that cars are ‘a symbol of freedom’ and that 82% of motorists (54% of non-motorists) agreed that cars are ‘a symbol of independence’ (see also Steg, 2005). While autonomy is most often identified by motorists, Thomas et al. (2014) found that UK users of different transport modes talked about the personal autonomy that their own travel modes afforded them, and how external changes could be a threat to their autonomy (see also Hiscock et al., 2002).

In considering the impact of the pursuit of autonomy upon transport users’ behaviours, it is important to separate the question of whether or not autonomy is *sought* through transport from whether or not transport *really provides* more autonomy. To the first question, there is reason to think that autonomy is important in transport behaviour: self-reported evidence, cited above, reflects Self Determination Theory (Ryan & Deci, 2000; Ryan et al., 2008), which identifies autonomy as one of three fundamental psychological needs humans pursue for their well-being and happiness (e.g. Reis et al., 2000). Beyond theory and self-reported evidence, however, little empirical evidence (to our knowledge) exists concerning correlations or causal associations between the pursuit of autonomy and transport behaviour.

To the second question (whether transport really provides autonomy), there is some evidence to suggest that autonomy could be important in the psychological benefits motorists derive from car ownership and use. Hiscock et al. (2002) found that motorists and public transport users report deriving security and comfort from their chosen travel modes. More broadly, these researchers provide some evidence that the feelings of security and comfort derived from car use are beneficial to motorists (Ellaway et al., 2003), including benefits to mental well-being (Ellaway et al., 2016; see also Groffen et al., 2013). It is important to make clear that the evidence that exists with respect to autonomy as a goal in transport choices also supports the theory that a self-reported pursuit of autonomy is a socially acceptable expression of the less conscious emotional or symbolic (e.g. status) goals one is pursuing (i.e. not merely practical goals (see Steg, 2005; see also Section 2.2.3)) through transport use, particularly car use.

Economising & affordability

Studies cited in the above paragraph rarely identify autonomy as the only motive for travel choices: along with autonomy, several instrumental (practical) motivations are often identified, principally financial costs and journey times. Transport users self-report considering financial costs when making transport decisions and are concerned about reducing the monetary costs of travel (Gardner & Abraham, 2007; Thornton et al., 2011; Hafner et al., 2017). Hafner et al. (2017) found that car buyers identified finance as a key factor influencing their choice of car. Graham-Rowe et al.

(2012) found that motorists identified cost minimisation as an influential factor in buying an electric car. Despite the concern for cost, evidence suggests that drivers may only account for fuel costs when considering the cost of their car journey and fail to consider other associated costs (e.g. purchase, road tax, etc.). This misperception or oversight in cost evaluation may contribute to the choice of cars over other transport modes, such as public transport (Gardner & Abraham, 2007).

The identification of *costs* indicates that, in contrast to autonomy, affordability places an extrinsic *limitation* upon individual demand for transport, rather than changing the desire for transport that individuals might have. So, it is useful to distinguish between economic barriers and motives. For instance, those who use non-car modes may be (financially) barred from a car ownership to which they aspire; similarly, owners of second-hand cars may aspire to ownership of new cars (e.g. Anable, 2005; Thornton et al., 2011). As discussed in Section 2.2.2, transport behaviour can be sensitive to transport prices in the aggregate, and certain transport behaviours differ with household income, which evidences the importance that transport users place upon economic means as a factor in their decision-making.

It is important, however, to consider that this decision-making need not be perfect. Users may apply only heuristic ‘rules of thumb’ when making economic decisions about travel and, therein, make suboptimal choices (Thaler, 1999; Flamm & Agrawal, 2012). For instance, stating fuel efficiency as litres per kilometre (gallons per mile), rather than kilometres per litre (miles per gallon), was shown (in choice experiments) to increase the number of participants who correctly chose the most fuel efficient car by approximately 20%; this is because humans tend (heuristically) to consider kilometres per litre (miles per gallon) as a linear metric of fuel efficiency, when it is not linear (Schouten et al., 2014).

Journey time and satisfaction

This factor falls under two aspects. The first is the transport user’s evaluation of their time.[5] The second is the transport user’s perception of this time. Economists infer the comparative value of travel time, under different circumstances, from observed choices (‘revealed preference’) and from hypothetical choice experiments (‘stated preference’). Abrantes and Wardman (2011; see also Wardman, 2001) provide a meta-analysis of the results of these studies in the UK context, giving overall estimates of comparative travel time values in terms of monetary cost. For instance, when running late, journey time was estimated to be 224% more valuable to transport users than other travel time and, similarly, journey time for business purposes was estimated to be 113% more valuable. By contrast (when compared to normal time spent travelling in a vehicle), journey time due to altered (delayed) departure times is less valuable (by 23%) and journey time due to service infrequency (‘headway’) is less valuable (by 45%); however, time spent driving in congestion is more valuable (by 34%). The value of travel time appears, also, to differ with journey distance: increasing by an estimated 1.6% for a 10% rise in distance travelled, on average. However, the nature of the evidence (choices) allows researchers only to *infer* (i.e. hypothesise or attribute) differences in choices to real differing motives, as opposed to differences between individuals or situations. For instance, one may infer that time is felt to be more valuable when one is running late

[5] By ‘evaluation’, we refer to relative monetary values of alternatives inferred from choices.

(this is an everyday experience). However, choice data, alone, does not exclude the alternative possibility that (for example) people who often run late are busy people who, due to their higher incomes, or higher status, place a greater value upon their time than those who do not tend to run late.

There is some evidence for the idea that transport users trade off travel time against other, more valuable, time. Gardner and Abraham (2007, pp. 190–91) describe how drivers regard travel time as 'dead time' that they could spend more usefully or pleasantly. Similarly, Mann and Abraham (2012) found transport users' beliefs about the time efficiency of public transport and driving to be positively associated with their self-reported public transport use and car use, respectively, which implies the existence of a motivation to minimise travel times (and perhaps to justify existing modal choice).[6]

However, there is also evidence that the quality of the *experience* of time spent travelling is important in how travel time is valued. Mann and Abraham (2006) describe how drivers consider travel time through the emotional (affective) experiences of journeys (e.g. stressful or unpleasant public transport incidents). Gatersleben and Uzzell (2007) found that journey stress was moderately positively associated with: (1) stated and perceived journey times (2) longer distances and (3) perceptions of a journey's difficulty, indicating that duration of journeys is correlated with their difficulty and stress: overall, easier journeys were the most emotionally positive journeys (see also Morris and Guerra, 2015). More broadly, Gatersleben and Uzzell (2007) found that boredom and stress were common emotions felt when travelling: boredom by public transport users and stress by drivers (relaxation and/or excitement were reported by pedestrians and cyclists). In line with these findings, Susilo and Cats (2014) found that transport users who judged their travel time to be reasonable (given the distance) were also satisfied with their journeys (driven and by public transport). So, while this review found no empirical evidence linking transport user experiences to transport choices by means of time evaluation, it is reasonable to suppose that the negative emotions of travel experiences motivate travel time minimisation, and more various travel time trade-offs, that are reflected in the economic evidence.

The second aspect of importance is travel time perception. Time perception is difficult to assess, even under laboratory conditions, and can be quite sensitive to individual differences and contextual factors (Matthews & Meck, 2014); therefore, by 'time perception' we simply mean the difference between how long travellers believe a journey took (or will take) and how long it *really* took, when measured objectively. That such differences exist is plausible, given that time is not perceived accurately, and that the evaluation of time is subject to bias (Li, 2003). The empirical literature, however, is relatively sparse (Tenenboim & Shiftan, 2016). Some early evidence from driving simulator studies indicates that time estimation may be influenced by the variation in velocity of travel (Leiser et al., 1991). Later studies have compared observed journey times to self-reports, finding a tendency for drivers to (a) over-estimate the duration of their driven journeys by up to 50% (Peer et al., 2014;

[6] In modelling the direct and indirect relationships between beliefs and behaviour, these authors did not include time efficiency beliefs in the car-choice model, though they did include congestion beliefs, which are likely comparable and more applicable to the driving context.

Tenenboim & Shiftan, 2016) and (b) further over-estimate the duration of unfamiliar journeys (Vreeswijk et al., 2014) and modes (Fujii et al., 2001; van Exel & Rietveld, 2010). Curl et al. (2015) studied subjective time estimates more broadly, comparing stated journey times in survey data to Geographic Information System (GIS) estimates of journey times. They found evidence that respondents over-report the duration of urban journeys and under-report the duration of rural journeys. However, they emphasise the methodological implications of their work, cautioning against psychological interpretation without further evidence (Curl et al., 2015). It has been argued (with some evidence) that these over-estimates are a reporting bias, rather than a perceptual or memory bias, and hence do not impact actual behaviour (Peer et al., 2014). However, a memory or decisional bias, at least for car drivers, is a possibility, but the extent and nature of any bias requires further empirical investigation to clarify: the evidence we found was open to other interpretations.

2.2.2 Structural factors

Income

Income is an influential factor in transport behaviour, particularly through car ownership and use, as rising income with respect to transport prices (considered further in Section 2.2.4) will increase the affordability of transport services. Allowing for other factors (e.g. household composition, company car use, urban residency, purchase and running costs), a rise in household income of £1,000 is estimated to increase the probability of car ownership (over not owning a car) by 25% (Wheelan, 2007). Similarly, Stapleton et al. (2017) estimated that a 10% increase in real income corresponded to a 5.5% increase in distance travelled. Furthermore, as illustrated in Figure 4b, evidence from the Department for Transport (2016) shows that the distance travelled by car or van (as either driver or passenger) and by trains and metros is higher in the top income percentage brackets. In contrast, distance travelled by bus is lower and walking and cycling are similar. Other research (Goodwin et al., 2004) suggests that a rise in income leads to multiple cars per household and to owning less fuel-efficient cars. However, it may be that car use increases only up to a threshold. Jahanshahi et al. (2015) estimated that those with annual incomes below £25,000 travel on average 31.2 fewer miles each week – much of this difference being attributable to not owning a car – whereas those with annual incomes exceeding £50,000 were estimated to commute on average 5.34 miles further each week.[7] The relationship between income and car ownership makes the effects of income upon public transport use difficult to estimate. Paulley et al. (2006) found estimates of changes in bus use with income to be *negative* overall: with a 10% increase in real incomes, estimated reductions in public transport use ranged between 5% and 10%. However, these authors caution that this estimate may be due to changing car ownership, which would mask smaller *increases* in public transport use with greater incomes. Research also suggests that, across the UK, taking longer journeys is more sensitive to income (Dargay and Clark, 2012). Dargay (2001) presents some important, qualifying, evidence with respect to income

[7] The link between income and transport, while it remains important, is weaker than it has been in the past, when transport was less affordable. Fouquet (2014) considered the economic relationship between income and travel between 1800 and 2010, estimating that, prior to the 1930s (and the affordable family car), increases in income had corresponded to far greater increases in land transport use (e.g. in 1895, a 10% increase in income would have corresponded to a 22.5% increase in land transport use).

and car ownership: when rising and falling incomes are considered separately, rising income is more influential, indicating that once one owns a car, declines in income do not lead it to be readily relinquished. Overall, the evidence indicates that income influences travel behaviour, particularly through increasing car ownership and use.

Built environment

Ewing and Cervero (2010) meta-analysed the available (mostly North American) literature with respect to the correspondence between different aspects of the built environment (e.g. density, land-use mix, accessibility) and individuals' transport behaviours.[8] The most studied aspect of the built environment – *density* (e.g. population or job density) – was *not* found to correspond to transport use to any great extent. However, different aspects of *design* (density and interconnection of streets) and *accessibility* (distances to common destinations) were found to be influential. Walking showed the clearest correspondence to different aspects of the built environment. Walking corresponded to: (1) *street density* (the concentration and interconnection of streets): a 10% increase was associated with a 3.9% increase in walked trips; (2) *accessibility* (distance to the nearest shop): 10% closer corresponded to 2.5% more walked trips; (3) *land-use mix*: 10% more diversity corresponded to 1.5% more walked trips. Recent research (Bornioli et al., 2018) elucidates psychological processes through which specific aspects of the built environment promote or discourage decisions to walk in urban areas. It is indicated that the local environmental impacts of traffic (noise, emissions) need to be radically reduced (or traffic removed altogether), and that infrastructural improvements should enhance the fluidity of progress and the perceived priority and safety of walking. Critically, however, the environment needs to offer a level of stimulation which is low enough to avoid stress but high enough to 'fascinate' (see Kaplan and Kaplan, 1989). Public transport use is positively related to street density and percentage of four-way road junctions; while driven distance is negatively related to proximity to workplaces and city centre (Ewing & Cervero, 2010). Other UK and European research confirms the importance of accessibility and design as key elements in transport behaviour (Dalton et al., 2013; Næss et al., 2017). Overall, urban designs that provide more interconnecting streets, as well as closer shops, jobs and city centres tend to have more walking and public transport use compared to driven distances.

Whereas diverse aspects of the built environment appear to be associated with walking in urban environments, it is *accessibility of destinations* (often distances) that is most influential upon car use. Importantly, there is evidence to suggest that, as well as having direct effects, the built environment also has indirect influences upon transport behaviour, such as through its impact upon car ownership decisions. For example, Melia et al. (2013) found potential for car-free residential development in the UK, but only where developments could be of sufficient scale to provide a genuinely low-traffic neighbourhood and if rail connectivity for long-range travel would be high.

[8] These authors' findings are reported without reference to statistical significance. Following their caution, we have not cited some findings from small numbers of studies, some of which were not statistically significant.

The effect of the built environment on travel behaviour is moderated by demographic factors. Jahanshashi and Jin (2016) find that *socio-demographic factors* are a greater influence (compared to the built environment) upon *rural travel*, whereas the *built environment* is a greater influence (compared to socio-demography) upon *metropolitan travel*, at least in respect of weekly distances travelled. Similarly, Jahanshahi et al. (2015) find that the associations between a number of socio-demographic factors and transport behaviours are mediated by differences in the built environment influencing car ownership. Stapleton et al. (2017) likewise estimate that a 10% increase in the proportion of people living in the five largest cities in the UK corresponds to a 16.9% *reduction* in distance travelled, indicating that living in large cities substantially reduces travel distances. Studies such as these provide evidence of a crucial role for the built environment in determining transport users' travel behaviour, often more than other structural or motivational factors, indicative of decision-making being significantly constrained or 'locked in' (see also Section 2.4).

It is also useful to evidence how *perceptions* of the built environment relate to transport behaviour and choices. Walking is associated with the perceived presence of local amenities and of supportive infrastructure (e.g. convenient, varying and pleasant routes/paths; while cycling is associated with perceiving moderate street connectivity (Adams et al., 2013; Ogilvie et al., 2012)). Along with car ownership, employment status, neighbourhood design, and attitudes to public transport, Aditjandra et al. (2013) found that perceptions of accessibility (to shops and facilities) and of safety were influential in decisions to drive. The authors conclude that perceptions, and attitudes/preferences help shape car users' driving behaviours in response to the built environment.

Transport infrastructure

Built environment accessibility is conceptually related to the availability of transport infrastructure and services and, as has been discussed, is associated with transport users' choices. However, the relevance of transport infrastructure, as a factor, warrants closer consideration. It has been argued that building roads, or increasing the capacity of existing roads, to alleviate traffic congestion, has the opposite effect: i.e., it induces demand for even more road use (Litman, 2017). Foley et al. (2017) study of the M74 extension in Glasgow found that changes in travel of all kinds were associated with living close to the new motorway and that car use increased with proximity to the new motorway, which the authors suggest could be due to increasing car ownership by those moving into, and already living in, the area. Similarly, a study of a new guided busway with foot/cycle path in Cambridge found that proximity to the new busway increased walking and cycling and decreased car use (Heinen et al., 2015). These two studies provide good evidence that, in these cases, individual transport behaviour changed substantially with the provision of new transport infrastructure.

Perceived travel constraints & control

Critically, accessibility of the built environment and travel infrastructure are not perceived uniformly. That is, constraints on behaviour are partly 'objective' (e.g., actual distance to bus stop) and partly 'subjective' (e.g. perceived effort or enjoyment of walking to the bus stop). Individuals may feel constrained by where they live, perhaps because of limited cycle lanes, limited bus services or the journey distance being too great to walk. There may also be limitations imposed by family members and dependents. Such structural barriers may exist, but an important element of whether people will switch to alternative modes of transport is their *perceptions* of the feasibility of using the alternatives and their confidence in their ability to do so (Klöckner & Friedrichsmeier, 2011). These considerations, alongside others, are typically discussed in terms of an individual's perceived behavioural control (PBC); that is, how much control an individual perceives themselves having over the transport choices they make. PBC over transport choices is typically found to be a strong correlate of car use and using alternative travel options (Hoffman et al., 2017).

Similar, although distinct from PBC, is the extent to which people perceive their lifestyle as being one which requires a high level of mobility. Haustein and Hunecke (2007) found that those with lower perceived mobility necessities (PMN; i.e. those who felt that being highly mobile was not part of their lifestyle) had more positive views regarding use of public transport compared to those with higher PMN, who felt that use of public transport was a waste of time and reduced their flexibility and independence. Consequently, those lower in PMN felt it was easier to use public transport, whereas those high in PMN felt it was impossible. As such, an individual's perceived needs for mobility may constrain their use of alternative modes of transport. This is in line with the car sharing literature which found that the perceived fit of a shared car to their lifestyle was a predictor of individuals' usage of car sharing (Kim et al., 2016; see Section 2.3.2).

It is important to be aware that, for those with disabilities, travel constraints may manifest themselves differently than for those without disability (who are the primary focus in the evidence presented above). Therefore, evidence outlined here cannot necessarily be generalised to those affected by disability, highlighting a need for further research (Wasfi et al., 2014).

2.2.3 Unconscious factors

Habit

Travel mode decision-making and choices can be influenced by strong habits, built up through repetition over time (Verplanken & Aarts, 1999; Thomas & Walker, 2015). Habits are automatic responses to contextual cues (Kurz et al., 2015), which could also (for travel choices) depend upon learnt routines (Verplanken et al., 1994). Thus, a commuter with a strong habit for commuting by car is unlikely to contemplate or seek information regarding alternative travel modes, all things being equal (Verplanken et al., 1997). Furthermore, transport users are probably unaware of the extent of their own travel habits (e.g. Bargh, 1989). The implication of the existence of strong travel habits, particularly for driving, is that information-based interventions (e.g. campaigns to increase public transport and/or walking and cycling) to change travel behaviour are unlikely to be effective with habitual transport users and, hence, such interventions might be most effective before travel habits have formed (Verplanken and Wood, 2006). Alternatively, times of change in the individuals' life circumstances may provide 'windows of opportunity' where disrupted travel habits can be exploited to engage the individuals in new travel modes and behaviours (Busch-Geertsema and Lanzendorf, 2015; Walker et al., 2015). More disruptive interventions, such as changes in transport infrastructure, technologies or costs, are more likely to alter established travel habits.

Symbolic/affective motives

Symbolic (identity) and affective (emotional) motives are both influential factors in decisions to use a car (Steg et al., 2001; Steg, 2005) and in car-buying decisions (Noppers et al., 2014). For instance, Steg (2005) found that motorists' car use was associated with the attractiveness to motorists of symbolic and/or affective aspects of cars but was *not* associated with the attractiveness to motorists of instrumental aspects of cars: those who used cars most seemed to value what a car symbolised, or how it made them feel, rather than its practicality. However, study participants were reticent about (or less aware of) possessing these motives (e.g. Jenson, 1999; Hafner et al., 2017). This means that demonstrating their importance is an empirical challenge. Baltas and Saridakis (2013) provide some evidence that, in the context of car choice decisions, symbolic motives can explain variation in car choices that is not explained by the practical attributes of the car, the car brand, or by socio-demographic differences between participants. In short, it is likely that motorists care about how cars and driving make them feel, and what driving, and car choice, help them identify themselves as (e.g. young, adventurous, wealthy, etc.). Unfortunately, it is difficult to estimate the comparative importance of this factor.

Social norms

Social norms are an influential factor in travel decisions. There is some evidence that social norms for car use are indeed associated with car use (Hoffmann et al., 2017; Lanzini and Khan, 2017). In the UK, Anable (2005) found the most committed motorists in her sample to possess the strongest social norms for driving. With respect to car buying, Pettifor et al. (2017), combining evidence from 21 studies, found a small to moderate effect ($r = 0.24$) of social influences (including norms) upon the adoption of alternative fuel vehicles. Like symbolic/affective motives, users appear reticent about, or unaware of, social norms as an influential factor. Normative influence may be an important element in encouraging modal shifts (Abrahamse et al., 2009), such as towards a UK cycling culture (Aldred and Jungnickel, 2014). As with symbolic/affective motives, however, evidence for their influence in comparison to other factors is limited, warranting further investigation.

2.2.4 Relative importance of factors

Travel is complex: it is complex in its nature, and through the variety of ways in which it is studied. Therefore, identifying the most important factor(s) in travel behaviour, of those identified as most important (above), is, ultimately, beyond the means of this review. However, using the academic literature, it is possible to discuss how one factor *might* become more important than another, but only once some important limitations upon this discussion have been identified.

First, dissimilar factors would seem to offer the best comparisons, because similar factors may be related, and so difficult to differentiate. For instance, *autonomy* (as a motive in travel) can be understood as a conscious motivating factor, but may be equally understood as being a less conscious symbolic/affective motive, or as the perceived absence of constraints and controls on travel decisions (Hunecke et al., 2007; see also Steg, 2005), all of which are identified, above, as separate factors. Second, few studies compare the effects of a range of different dissimilar factors upon travel decisions. Therefore, the best estimate available is a comparison of findings between different studies. Unfortunately, this approach is of limited value.

For instance, the effect of building a new road upon car use may be demonstrated with an empirical study (e.g. Foley et al., 2017) to be a strong effect. This strong effect, however, is likely to depend upon other factors identified in this review: for example, a new road might shorten journey times, improve access to destinations, improve perceptions of control over travel and of the opportunities for autonomy through driving. A study can attempt to take these factors into account, but it is usually sufficiently challenging to show that a new road changes car use behaviour. Therefore, in considering different results between studies, it is necessary to be aware that other factors will likely be involved.

Dalton and colleagues (2013), in their study of associations between travel mode choices and elements of the built environment, found moderate to large associations for each element, allowing for other elements. As Ewing and Cervero (2010) have argued, the importance of these elements is likely cumulative, amounting to a much stronger influence when considered together. The moderate to strong positive association between road-building and car use (Foley et al., 2017) would appear, on average, to be slightly stronger than the associations between habit and travel mode choice and between control beliefs (PBC) and travel mode choice (although these associations are typically moderate to strong, also; Hoffmann et al., 2017; Lanzini & Khan, 2017). Social norms would appear to be less closely associated with travel decisions (Hoffmann et al., 2017; Lanzini & Khan, 2017; Pettifor et al., 2017). However, as argued in the previous paragraph, it is vital to also consider studies in which different factors are compared as explanations for travel behaviour. Studies exploring the same correlates of walking and cycling in affluent Cambridge (Panter et al., 2011) and less affluent Glasgow (Ogilvie et al., 2008) found accessibility (as proximity) to be important. Studies by both Panter and colleagues (2011) and Ogilvie and colleagues (2008) broadly support the importance of accessibility (as proximity) in decisions to walk or cycle, with Panter and colleagues finding this to be more important than psychological factors (attitudes, perceived behavioural control over fitness, social norms and habits). However, it is useful to add that while Panter and colleagues (2011), with a more affluent sample from Cambridge, found decisions to walk to be related to the perceived pleasantness of the route, Ogilvie and colleagues (2008), with a less affluent sample from Glasgow, did not.

Survey evidence from an Australian study of university students indicated that when cost, accessibility and travel times were compared, only cost and accessibility were found to be important explanations for travel preferences (Collins & Chambers, 2005). Aditjandra et al. (2012), modelling travel mode choice in Tyne and Wear (UK), include several different factors in their analysis. They found that the decisions to drive were influenced by household incomes only in so far as car ownership changed, and not to any great extent by comparison to accessibility (proximity to shopping centre/town centre, and/or proximity to public transport system) or the positive utility of travel (which was discussed above with respect to travel time and satisfaction).

By and large the literature considered here, though by no means complete, tends to support the comparative importance of structural environmental factors (the built environment and infrastructure), and perceptions of this, over particular motives. The evidence with respect to income is mixed, indicating a more sophisticated relationship.

2.2.5 Interventions to change transport decision-making & behaviour

Systematic reviews relating to interventions to reduce car usage (or promoting walking and cycling as alternatives to car use) have similarly concluded that evidence for evaluating the effectiveness of car use interventions was often lacking or unreliable and lacked the necessary control groups to allow causality to be inferred (Graham-Rowe et al., 2011; Ogilvie et al., 2004; Arnott et al., 2014). With this in mind, evidence and available conclusions for key car use interventions are overviewed below.

Prices & charges

As noted above, transport service affordability reflects both ability to pay and the price of transport goods and services. Stapleton et al. (2017) estimated that fuel price increases of 10% correspond to reductions in distances travelled of 2.6%, in the long run. Goodwin et al. (2004) estimated that a 10% increase in fuel prices corresponds to a similar reduction in driven distance in the long run (1% in the long run; 2.9% within a year). Goodwin and colleagues also estimated that a 10% increase in fuel prices correspond to a 2.5% reduction in fuel use (6.4% in the long run) and a 0.8% reduction in the vehicle stock (2.5% in the long run). These authors note that the reduction in distance is proportionally less than the reduction in fuel use, indicating that drivers achieve sizable fuel savings without driving any less, in response to fuel price rises. This was attributed to changes in fuel economy (presumably through fuel efficient driving, fuel efficient car buying and suppliers increasing the fuel efficiencies of their cars). We have, in the following paragraph, considered how far the evidential basis for this assumption could be clarified using relevant literature.

Long-run research evidence about consumer choices is scarce, although the European car sales market has seen a near inexorable rise in consumer preference for diesel cars, which overtook petrol vehicle sales in many national markets, in response to differential taxation measures (a trend recently halted because of the threat of regulations on the future use of diesel vehicles due to noxious emissions problems). However, there is evidence (from Norway and Switzerland) that car buyers value fuel economy in cars they have recently bought: the emissions/fuel economy of cars recently purchased was associated with both attitudes to fuel efficiency in cars and future intentions to buy fuel efficient cars (Peters et al., 2011; Nayum & Klöckner, 2014). There is also evidence that cars in Germany are priced, particularly in the second-hand car market, according to their fuel efficiency (Kihm & Vance, 2014); while US research similarly suggests that consumers are aware of fuel prices and use them in their judgements of future prices (Anderson et al., 2013). However, there is some uncertainty concerning the accuracy of fuel efficiency judgements by consumers (Turrentine & Kurani, 2007; Greene, 2010).

Paulley et al. (2006) estimated that a 10% increase in the cost of fares corresponds to a 4% reduction in bus use (10% in the long run); to a similar fare change, metro use reductions of 3% (6% in the long run) are estimated. Litman (2004) indicates that rail is more sensitive to price: a 10% increase in rail fares corresponds to a 6.5% reduction in rail use (11% in the long run). Dargay (2008) largely agrees with these estimates.

Parking charges can be effective in reducing car use, but only if correctly calibrated and implemented (Santos et al., 2010: part I, pp. 25–27; Marsden, 2006); for instance, charging for the length of time parked can lead to *increased* traffic (Glazer & Niskanen, 1992). There is evidence that parking charges have no long-run detrimental impact upon local economic activity (Marsden, 2006).

Congestion charging seems to have been broadly successful in London – congestion was reduced for the first four years after its introduction, but returned to former levels as cyclists and bus users replaced car users (Santos, 2008). However, there is less clear evidence for the long-run benefits of congestion charging: it is possible that other, concurrent, trends in London transport account for observed changes (Givoni, 2012).

Service provision and infrastructure change

Public transport service quality is difficult to assess, with researchers emphasising what is quantifiable (number of services, service intervals, regularity) at the expense of qualitative aspects (cleanliness, customer service) that could be as important, if not more so (Litman, 2008). There is some evidence that the regularity of metro services is as important as cost of fares with respect to their use: a 10% increase in regularity corresponded to a 5.1% increase in use in the long run (Graham et al., 2009); quantified service quality and service prices seem to be broadly comparable in their effects (Paulley et al., 2006; Dargay, 2008, p. 80).

The evidence base for pedestrianisation is less complete, and changes in acceptability of the measure by local people may introduce bias into available self-report studies (Melia & Shergold, 2016); however, the available evidence points to reductions in road use, with positive impacts upon local business, within pedestrianised areas, in the long run (Hass-Klau, 1993; Melia & Shergold, 2016).

Urban development, given our discussion of the built environment (Section 2.2.2), is an important basis for lasting interventions that establish transport behaviour for many years to come (Santos et al., 2010; Rode et al., 2014). However, evidence is usually correlational; there are few reliable studies of how deliberate changes in urban form impact transport user behaviour. Indeed, the outcomes of these policies unfold over extended periods of time, with many complicating factors (e.g. Carmona, 2009; Carmona, 2015) to which observed changes might be wholly or partly attributed. Though the transport changes with the redevelopment of the London Docklands area, for instance, have been identified as beneficial with respect to modal choice (Metz, 2012; Metz, 2017), as has land use policy in the Netherlands (Schwanen et al., 2004), evidencing the efficacy of these changes as distinct from others is rarely possible (Schwanen et al., 2004; Ogilvie et al., 2014). There is a debate as to how far it is realistic for decision-makers to expect a level of evidence from real-world interventions that could only be produced from randomised control trials (Melia, 2015).

Technology

Non-vehicle telecommunication. Beyond the larger trends around transportation and advances in ICT (sections 2.3 and 2.4), there are opportunities afforded by these technologies to facilitate transport behaviour changes (Santos et al., 2010). In the UK, the uptake of teleworking has not been as rapid as some anticipated in the early days of teleworking in the 1980s and 1990s (Felstead, 2012; Melo & de Abreu e Silva, 2017). Current evidence for the efficacy of teleworking in reducing transport in the UK is mixed, with an indication that only those who telework most frequently reduce their commuting significantly (Melo & de Abreu e Silva, 2017). This is not to say that teleworking does not have the potential to be effective, particularly for working parents (Vilhelmson & Thulin, 2016); but it is plausible that significant barriers exist in the occupational context of teleworking (Santos et al., 2010; Hyes, 2014; Vilhelmson & Thulin, 2016).

Online shopping contributes most to road traffic and emissions, potentially, in its 'last mile' (i.e. in using small vehicles to deliver from the local depot to the consumer; Edwards et al., 2010). Traffic from light goods vehicles is the vehicle category which has seen the highest growth in recent years. One observational case study of deliveries to student halls of residence estimated that consolidating these deliveries could reduce daily trips from 56 car/van journeys to just one or two lorry journeys. This service was estimated to cost an additional £18 *per capita* per year, so, this additional cost would accrue to the implementer of such a policy (a subsidy), or else could be passed on to the consumer as a price increase (Cherrett et al., 2017).

In-vehicle fuel-efficiency feedback

Van Krevelen and Poelman (2010) list several developing applications for 'augmented reality' in transport, including information displays. Some evidence is available concerning the efficacy of fuel efficiency feedback to drivers to encourage more fuel-efficient driving behaviour ('eco-driving'). Eco-driving has the potential to reduce fuel use by around 45% (Sivak & Schoettle, 2012). This potential is, in practice, an upper limit and, while few reviews exist of eco-driving intervention studies, savings ranging from 5% to 20% have been recorded (Vaezipour et al., 2015). A closer understanding is necessary to achieve better, and more consistent, outcomes. With respect to technology, there is some evidence to suggest that haptic (touch) feedback, by means of vibrations through the accelerator pedal, might be a safe and effective means of feeding back fuel-efficiency information to the driver (McIlroy et al., 2017). Several studies indicate that attitude/psychological factors likely determine the extent to which feedback is effective in encouraging fuel-efficient driving; for instance, Stillwater et al. (2017) found the fuel savings observed in their study of visual feedback upon eco-driving, to be almost entirely attributable to a sub-sample of study participants who were interested in the technology and did not already drive fuel efficiently (see also Ünal et al., 2017).

Nudges and 'soft' policy

'Soft' policy interventions use information (about consequences and alternatives) to change transport behaviour (Santos et al., 2010); they 'aim to change people's travel behaviour through persuasion rather than cost' (Wall et al., 2017, p. 106). In the UK, 'soft' policy interventions have been at the heart of 'smarter choices' campaigns, including such measures as encouraging travel planning (to economise upon journeys), public transport marketing and travel awareness campaigns (Cairns et al., 2004; Wall et al., 2017). Möser and Bamberg (2008), reviewing available literature on the efficacy of 'soft' policy interventions to reduce car use, found a small effect (an estimated 7% reduction in car use) across 141 studies, but, in common with other reviews of transport behaviour-change interventions (e.g. Graham-Rowe et al., 2011), tempered their conclusions due to the poor evidential quality of empirical studies available. ‘Soft’ policy interventions seem to rely upon the psychological factors that influence transport choices, in addition to effective marketing practices (Sloman et al., 2011, pp. 46–48), and these include the application of ‘nudges’ (Thaler & Sunstein, 2008), which are subtle aspects of the way a choice is presented (the ‘choice architecture’) that can steer individuals into making ‘better’ decisions. For instance, recent research has shown that applying ‘nudges’ to car labelling conveys cost, fuel efficiency and emissions information to car buyers more effectively than car labels without nudges (Codagnone et al., 2016). The weakness of ‘soft’ transport policy interventions such as these is that they may run counter to the prevailing culture: norms, practices and habits (see Section 2.2.3) that tend to bring transport behaviour back to the status quo after the intervention has past (Goulden et al., 2014; Barr & Prillwitz, 2014). Therefore, to have any long-term impact they might need repeating at intervals.

2.2.6 Summary

- Transport users’ decisions are shaped by several factors: self-reported motivations, unconscious motivations and structural factors (the transport environment and one’s circumstances).

- The most important self-reported motivations are: (a) personal autonomy (b) economising and (c) journey times and satisfaction.

- Transport users report using transport modes that give them autonomy (freedom, independence) in their travel. Beyond self-reports, there is less ‘hard’ evidence for this, though there is some evidence that autonomy in travel (through car ownership) can be psycho-socially beneficial.

- Transport users report making economising transport decisions: financially economising, and economising time. In this latter respect, shorter journey times are associated closely with journey satisfaction.

- Further: (1) journey time/satisfaction is linked to positive/negative emotions while travelling and (2) it is a possibility that journey times could be misperceived, perhaps during ‘stop-start’ journeys, affecting journey satisfaction.

- The most important structural factors are: (a) income, (b) the built environment, (c) transport infrastructure and (d) perceived travel constraints/controls.

- Incomes are related both to travel decisions and car ownership decisions, which reflect actual limits on travel and motives to economise: overall, increases in income tend to increase car use and reduce public transport use, but motorists are more reluctant to relinquish car ownership entirely with reduced incomes.

- Accessibility (usually distances between common destinations) appears to be the most important element in the built environment for travel decisions.

- Driving is associated with accessibility/proximity to workplaces and town/city centres from one's home. By contrast, walking is associated with a more general accessibility/proximity of common destinations.

- Decisions to walk are also related to positive or negative experiences, the presence of traffic in the area, and traffic impacts (noise, emissions).

- This is related to the way transport infrastructure shapes travel decisions. Studies of the impacts of the new M74 extension in Glasgow and of the new guided busway/footpath network in Cambridge have shown that building these infrastructures likely lead to changes in travel behaviour by local people: a motorway leads to more driving, and travel in general; a guided busway/footpath network leads to more walking and cycling, and less driving.

- Crucially, these structural factors (income, built environment, transport infrastructure) should have both an 'objective' effect upon travel behaviour (really affording or limiting travel options) and a 'subjective' effect upon travel behaviour (making travel options seem more or less 'realistic'): if transport users do not perceive themselves as having viable options, for example if they see themselves as dependent upon car use for mobility and access, then they will not change their travel behaviour.

- The most important unconscious factors are: (a) habit, (b) symbolic/affective motives and (c) social norms.

- Importantly, studies have found evidence that these factors are influential, though most transport users would not recognise these unconscious influences.

- Habits develop from repeating routine journeys; for instance, the habit of taking the car to work, rather than the bus. Habits, once acquired, are hard to break, and make the habituated traveller less likely to contemplate viable alternatives.

- Symbolic (identity) and affective (emotional) motives have been shown to be influential in car use and car-buying behaviour: while people often cite the more instrumental motives (autonomy, economising, time reduction) that they are most aware of when travelling, their answers, considered carefully, often betray affective and symbolic motives (e.g. feeling good while driving, driving a car that reflects your personality) that have been shown to be equally, and sometimes more, influential across several studies.

- Similarly, one can be conforming to social norms when travelling: the unwritten rules and expectations of others (family, friends, colleagues, society). Social norms for car use are associated with car use behaviour, and this association is strongest for committed motorists.

- Several travel behaviour-change interventions were discussed. Broadly, while some interventions have been shown to be effective, others are not well evidenced, and so it is unclear whether they are effective, or what other consequences might arise from intervention.

- Fuel prices influence car use, but it is difficult to clarify how far reductions in car use are made, rather than buying more fuel-efficient cars (as well as fuel-efficient driving behaviour).

- Fare reductions, and public transport quality improvements, show comparable increases in public transport use. Congestion charging in London is widely identified as a successful intervention but its long-term effects are unclear.

- Car parking charges can be effective in reducing car use without impacting local economic activity, but can increase traffic if they are not correctly calibrated.

- Pedestrianisation is less well evidenced – available evidence indicates that it reduces road use within the local area and is good for local trade.

- Large-scale urban re-development projects are difficult to assess: the long-run impacts are not clear.

- New information technologies have the potential to encourage teleworking (working from home), reducing traffic, but the growth of teleworking in the UK has been less than anticipated, possibly due to barriers in occupational contexts (e.g. staff monitoring).

- Online shopping is most impactful in the 'last mile' of the delivery (from the depot to one's home), so local collection points have the potential to reduce associated traffic and emissions.

- In-vehicle fuel-efficiency feedback is effective in reducing fuel use, provided there is room for improvement in individuals' driving styles.

- 'Soft' policy interventions (using information to raise awareness about travel alternatives) show comparably small effects upon actual travel behaviour.

2.3 Transport users' preferences for the transport system

As outlined in Section 2.2, there are a number of factors that influence transport decision-making. These were largely discussed with respect to well-established transport modes. The following section outlines public preferences for emerging transport technologies and services to identify psychological drivers and barriers to uptake of these emerging transport modes. Modes are divided into ownership (electric vehicles and autonomous vehicles) and sharing based models of transport (car sharing, peer-to-peer and shared autonomous vehicles).

2.3.1 Ownership

Electric vehicles

Electric vehicles (EVs) offer the consumer the opportunity to keep many of the features of a traditional car (i.e. an internal combustion engine vehicle; ICEV), while removing the production of greenhouse gases at the point of use. However, the uptake of EVs faces barriers, largely because of the inevitable comparison to traditional cars (Graham-Rowe, 2012). For instance, the public have been found to be concerned with the higher costs of EVs, limitations on driving distance (due to limited battery capacities), charging times, and availability of public charging infrastructure (Carley et al., 2013; Graham-Rowe, 2012; Jensen et al., 2015). Beyond these issues relating to functionality, however, concerns for the symbolism of EVs and how this interacts with people's identities have also been found to be important (White & Sintov, 2017). These factors are discussed further below.

Cost, functionality and environmental credentials

The higher upfront costs of EVs compared to ICEVs are frequently found to negatively affect people's intention to purchase an EV (Carley et al., 2013; Graham-Rowe, 2012; Jensen et al., 2015). This concern about higher upfront costs is sometimes countered with the argument that the electricity needed to run the EV is cheaper than petrol or diesel; therefore, savings can be made over time with the EV. However, the lower cost of the electricity has been found not to offset the higher upfront purchase cost of EVs (Coffman et al., 2017). Furthermore, through the experimental manipulation of survey information, Dumortier et al. (2015) found that presenting fuel saving information to participants did not influence the participants' intentions to buy an EV. It was found, however, that presenting total costs of ownership (TCO; includes fuel and other operating costs), which indicated a saving over time with EVs compared to ICEVs, did have a positive effect on intention to purchase. The challenge is that, depending on the country or region, estimations of the TCO for EVs can be higher than ICEVs (Coffman et al., 2017). As such, lower TCO of EVs is also not an argument that EV companies will be able to use presently. A review of studies which have evaluated TCO suggests that EVs may be more economically attractive by 2030 and, therefore, decisions to switch to and adopt them will be less inhibited by cost concerns by considering the relative TCO (Andwari et al., 2017).

Concerns relating to battery capacity, charge times and public charging infrastructure interact. For instance, in stated preference studies, concern for battery capacity (i.e. range anxiety) has been found to decrease if charge times are shorter and/or if more public charging infrastructure were available (Dimitropoulos et al., 2013; Coffman et al., 2017). In support of this, there is evidence that people would be willing to pay more if it meant getting faster charging times (Hackbarth & Madlener, 2013). Therefore, the concern for the range of EVs may be mitigated by the availability of rapid charging and of public charging stations.

A less studied, but potentially important consideration in EV functionality is their potential to have environmental benefits. For instance, people indicate concern for the sustainable nature of the manufacturing process and electricity sources used in the running of EVs (Hawkins et al., 2013), and this has been found to influence intentions to purchase them. For instance, Degirmenci and Breitner (2017) found that, while the majority of participants felt that EVs were a positive contributor to environmental sustainability, many were concerned that the electricity used to charge them would need to come from renewable sources if EVs are to offer a ‘true green alternative’ (p. 251). Consideration of the environmental performance of EVs was then found to be a stronger influence on participants’ intentions to adopt them than either their desire for price value and range confidence (although both these attributes were still a positive influence). Therefore, striving to make EVs a truly more ‘green’ alternative to ICEVs by reducing the carbon intensity of electricity generation is an important factor in the adoption of EVs (Andwari et al., 2017).

Assuming that the current trends of EV development can be maintained, costs of EVs, which may already be coming down (UBS, 2017), will become more competitive with ICEVs and so cost will be less of a barrier (Wu et al., 2015). Equally, the availability of EVs to lease would lower the upfront cost of EV ‘ownership’ (as well as reducing any concerns about maintenance; Nurhadi et al., 2017). Similarly, battery capacities are likely to increase, charging times are likely to reduce, and charging infrastructure is likely to be further developed (Andwari et al., 2017), especially within countries like the UK. These developments may remove the functional barriers to EV adoption (Coffman 2017; Graham-Rowe et al., 2012). However, other considerations, which are typically discussed as demographic and psychological factors, may have an important role for accelerating EV adoption ahead of these advances (Li et al., 2017; Lane & Potter, 2007). Political factors are important in influencing decision-making contexts and social norms, and the decision by the UK Government to end the sale of pure ICE cars from 2040 will likely be influential in this sense.

Demographics and early adopters

As a guide to the early EV market, researchers have explored the characteristics and motivations of people who have already adopted EVs. For instance, in their sample of 340 early adopters in the United States (US), Hardman et al. (2016) found that early adopters of EVs had high individual incomes (>$90,000 per year), were more likely to have a university-level qualification, owned more vehicles as a household than the US average, and were predominantly (92.6%) male. No clear trend for age was found, although most respondents were between 35 and 65 years old and thus not (relatively) younger drivers (see also: Vassileva & Campillo, 2017). Furthermore, a comparison of EV owners with non-EV owners showed that EV owners have higher levels of environmental concern, are more engaged with the environment, have more technology-orientated lifestyles and are more open to change (Axsen et al., 2016), although EV adopters are also heterogeneous in their motivations (Axsen et al., 2015).

While there are indications that early EV adopters are predominantly male, Vassileva and Campillo (2017) found no difference between the motivations for adopting EVs between their male and female respondents. Similarly, Degirmenci and Breitner (2017) found that neither gender nor age had a significant influence on people's attitudes towards EVs. Therefore, understanding the predominance of male EV adopters or, indeed, the lower uptake among female drivers, requires further exploration. It should be noted that there may also be a response bias to early adoption surveys and these surveys may not capture the fact that the EV purchase decision may have been made as a couple or as a family; therefore, the predominance of male adopters may be inflated (Hardman et al., 2016).

Consumer innovativeness

A key characteristic of early adopters of technological advances is considered to be their innate attraction to new and/or unique innovations. Such consumer innovativeness has been established as an important component of individuals' adoption of new technologies (Bartels & Reinders, 2011). Indeed, Morton et al. (2016) found that adoptive innovativeness (alongside concerns for the functionality of the EV) significantly increases preferences for EVs. However, while innate innovativeness might motivate an individual's interest in a new technology, there are a number of variables which may impede actual adoption (Midgley & Dowling, 1978). For instance, the individual will still need to be interested in the category of technologies to which the innovation belongs, advice from trusted sources will be influential and other situational or economic factors may restrict opportunities to purchase a new innovation, such as finances. As such, innovative consumers may be early adopters of one technology, but may be late adopters with a different technology.

Experience

It is argued that some of the concerns people might have about the functionality of EVs might be mitigated once they have had an opportunity to experience using them (Burgess et al., 2013). However, evidence for this argument is mixed. For instance, in a survey of American early EV adopters, EVs were rated as having far superior running costs, fuel economy and performance compared to ICEVs. However, purchase cost, driving range and time to refuel were still rated as slightly worse (Hardman et al., 2016). Likewise, while concerns about speed and acceleration may be addressed by experience, Jensen et al. (2015) found that, after a three-month trial of EVs, participants' concern for the driving range of EVs had nearly doubled as they found the EV unable to meet their needs. However, despite experience of EVs potentially highlighting some disadvantages of EVs, it may also highlight some advantages and so, in their review, Lit et al. (2017) concluded that experience is an important factor in the adoption of EVs (Schmalfuß et al., 2017; Degirmenci & Breitner, 2017).

Symbolism, identity and values

When purchasing a car, people consider not only practicality and costs, but also the perceived image the car projects, what that symbolises and whether it is congruent with their self-identity (Rezvani et al., 2015; Burgess et al., 2013; Hafner et al., 2017). This same concern for symbolism and identity has also been found in people's considerations of EVs (Rezvani et al., 2015).

As noted above, EVs are promoted as being more environmentally friendly alternatives to traditional cars (Adwari et al., 2017). Accordingly, some studies have found that those who have a pro-environmental self-identity were more likely to have positive perceptions of an EV (Schuitema et al., 2014; Noopers et al., 2014) and that being an early adopter of a 'green' technology was itself a source of a positive social identity for some EV users (Graham-Rowe et al., 2012). More than just having a pro-environmental identity, it may be important that the vehicle symbolises this identity. For instance, belief that owning an EV would promote an image of being pro-environmental was a strong, positive influence on participants' impressions of EVs, their willingness to buy EVs, and how much they were willing to pay for EVs (White et al., 2017).

In the study by White et al. (2017), pro-environmental image was stronger and more consistent on the three outcomes than the instrumental attributes of purchase cost, maintenance cost, fuel cost, charging convenience, and estimated EV range. It was also stronger than the belief that owning an EV would promote an image of being a social innovator, although this too had a positive effect on participants' impressions of EVs and willingness to buy EVs. Interestingly, participants' concern about climate change did not have a direct influence on willingness to buy EVs. Concern for climate change only had an influence because it influenced people's belief that owning an EV would promote an image of themselves as being pro-environmental and social innovators. This suggests that aligning the symbolism of the vehicle with an individual's values and identity is important for EV adoption (cf. Murtagh et al., 2014). Indeed, the rise of high-performance luxury electric cars, most notably from Tesla, the publicity for which emphasises the traditional automotive values of performance, safety and novelty far more than 'green credentials', will likely, probably intentionally, weaken the association of EVs with a particular political-consumer identity as the consumer technology matures.

Social influence

A potentially very important aspect of EV adoption will be social influences. For instance, Pettifor et al. (2017) conducted a meta-analysis of 21 studies which had explored the influence of three types of social influence on vehicle choices: interpersonal communication (exchanging information with others); neighbourhood effect (observing those in close proximity); and conformity with social norms (either perceptions of what others do [descriptive norms] or what other people will approve/disapprove of [injunctive norms]). It was found that all three forms of social influence have an effect on individuals' vehicle choices. Furthermore, Jansson et al. (2017) found indications of the neighbourhood effect and interpersonal communication and/or social norms. They found that having family members and colleagues who own alternative fuel vehicles (AFVs, including EVs) was positively related to the individual having an AFV (although these effects were no longer seen when demographic variables were entered into the model) and the presence of AFVs in the neighbourhood also positively influenced AFV ownership and continued to do so even with the demographic factors were entered. This suggests that the presence of AFVs in the neighbourhood may be important for diffusion of EVs.

These social influences may be strong enough to overcome concerns about driving range and price. For instance, Cherchi (2017) explored three aspects of social conformity, which included social norms, but also information conformity (relying on the guidance of an individual or group when ‘correct’ action is ambiguous) and social signalling, which relates to image (the image that the individual wants others to have of them). Each form of conformity has a strong influence on choice of EVs. Indeed, the desire to conform compensates for some of the negative effect of higher costs or lower ranges of the EV options (see Barth et al., 2016).

Autonomous vehicles

While EVs do not deviate too far from the traditional car, autonomous vehicles (AVs) have the ability to disrupt current driving choices and behaviour (Krueger et al., 2016). It is argued that AVs will offer greater safety than traditional cars through reduced crash risks (Bansal et al., 2016), environmental benefits through more efficient driving (Howard & Dai, 2014), the possibility to engage in work and leisure activities while being transported in a personal (or shared) vehicle (Le Vine et al., 2015), and greater mobility for elderly people (Fagnant & Kockelman, 2015) and/or individuals with barriers that might otherwise prevent them from driving a non-autonomous vehicle. However, there are also potential negative consequences of private ownership of AVs; for instance, increasing the frequency of short-distance journeys and reducing the use of public transport services (Krueger et al., 2016). These benefits and negative consequences are largely speculative at this stage, however, as AVs are yet to be available or utilised at scale.

Clark et al. (2016) undertook a review of public attitudes research into AVs, identifying a range of outputs from commercial organisations, consumer and motoring organisation and academics. As with EVs, concern for the cost of AVs, relative to traditional cars, is frequently found (Haboucha et al., 2017). In a survey of 17,400 vehicles owners, 37% indicated an interest in purchasing a fully autonomous car. However, this percentage reduced to 20% if additional costs were introduced (J.D. Power and Associates, 2012). Indeed, Schoettle and Sivak (2014) found, in a survey of the US, UK and Australian public, that there was a desire in the majority of respondents to have automation; however, a majority were also unwilling to pay extra to get it. These concerns for cost may also not be related to income (Howard & Dai, 2014).

Concerns that are more unique to AVs are related to safety for both passengers and other road users (Schoettle & Sivak, 2014), fear of a technical failure (Bansal et al., 2016), an unwillingness to relinquish control of the vehicle (Howard & Dai, 2014), concern for threats from hackers (Bansal et al., 2016; Schoettle & Sivak, 2014; Kyriakidis et al., 2015), and concerns relating to the adequacy of AV laws and liability (Fraedrich & Lenz, 2014; Howard & Dai, 2014). For instance, when considering themselves as passengers (i.e., not required to drive the vehicle as it will drive itself) in an AV, participants in one study felt they were at more risk than when considering themselves as pedestrians with AVs on the road (Hulse et al., 2018). However, although there are concerns for the safety of AVs, the possibility that AVs will reduce the risk of crashes is seen as a positive feature (Howard & Dai, 2014; Schoettle & Sivak, 2014; Bansal et al., 2016).

Giving up control of driving to the AV has been found to be influential; however, this may be subject to a number of influences. For instance, individuals' current mode of transport may be important as those who commute as the sole occupier of their vehicle and cyclists were found to be more concerned with giving up control than those who primarily carpool or walk. Furthermore, frequent technology users were less concerned with control and also cost, and were found to have a higher intention to use AVs. In contrast, those who attached greater value, image and prestige to car ownership were more concerned about giving up control of driving to AVs and were less interested in AVs as they enjoyed the driving experience. Furthermore, Hohenberger, Sporrle and Welpe (2016) found that anxiety negatively influences attitudes towards AVs, while pleasure positively influences attitudes towards AVs. However, men are more likely to anticipate pleasure from the use of AVs, whereas women were more likely to anticipate anxiety. The authors suggest that reducing anxieties related to AV use and accentuating the pleasurable aspects may reduce the differences between the genders.

Finally, those who placed greater value on the fuel economy of a vehicle were less concerned about giving up control (Howard & Dai, 2014). Ultimately, people may be more likely to use AVs if they can take back control if needed (Accenture, 2011), although there is evidence that the handover event itself brings risks (Merat et al., 2014; Morgan et al., 2017); this suggests that future regulations may seek to limit this practice.

Trust influences acceptability, adoption and continued use of automation technology (e.g. Lee & See, 2004; Parasuraman et al., 2008) and will be a key factor related to the future use of autonomous vehicles (AVs). It is influenced by the reliability, resilience and robustness of the automated system (e.g. Hancock et al., 2011) and all of these factors are affected (positively or negatively) by personal experience and learning first- or second-hand from others. Personal experience is perhaps most important given that for trust to be accurately measured, the user needs to become familiar with the system by allowing it to make decisions about things that they would have previously done themselves (e.g. Lee & See, 2004). Given that AVs are an emerging technology and most people have no personal experience with such systems, it is difficult to gauge current levels of trust in them. Nevertheless, we can look to the literature for guidance.

Trust is strongly related to acceptance of automation and reliance upon it (e.g. Lee & Moray, 1992; Lee & See, 2004; Pavlou, 2003). These are key aspects of the Automation Acceptance Model (Ghazizadeh et al., 2012). Humans are far more likely to adopt automation if they trust the system and reject it (sometimes indefinitely) if they do not (Pop et al., 2015). Automation rejection can occur due to factors such overuse, abuse and not fully understanding (i.e., misuse) how to use the system (Parasuraman & Riley, 2007). In order to positively influence trust in automation, users need to believe that the system (1) is logical, understandable and predictable (2) always performs tasks accurately and effectively, and (3) offers adequate assistance in a responsive manner.

Few studies have investigated trust in AVs and those that have mainly focus on Level 3[9] conditional automation where the vehicle is self-driving some but not all of the time. Some have adopted survey methods (e.g., Choi & Ji, 2015) and others have used experimental designs using driving simulators (e.g. Abe et al., 2015; Gold et al., 2015; Körber et al., 2018). Using a survey method, Choi and Ji (2015) found that perceived usefulness and trust are related to intention to use AVs and that factors such as technical competence, system transparency and situation management are also positively related to perceived trust. Using a driving simulator with younger (under 30 years) and older (over 60 years) participants, Gold et al. (2015) measured trust before and after 15–20 minutes of automated driving with embedded takeover situations. Despite finding a marginally non-significant increase in trust post- versus pre-simulator experience across the sample, trust among the older adults increased significantly. It is key to note that Gold et al. (2015) instructed participants that the automation was faultless. Körber et al. (2018) conducted a similar simulator study where one group received introductory information to *promote* trust in the system and another group received information to *lower* trust. Participants in the 'trust promoted' group engaged more with a non-driving related task and looked less at dashboard instruments and the road ahead. Trust promoted participants also took longer to take over controls following a handover request and six participants in this group collided with an obstacle compared to none in the 'trust lowered' group. To our knowledge, only one study to date has examined trust in a road-based AV, compared to a simulator, performing different types of manoeuvres (Morgan et al., 2018). Morgan et al. (2018) reported that trust was high across both platforms, albeit generally higher in the simulator. This was not the case for all events: for example, trust in the road-based AV was higher for some right turns. Despite these findings, Morgan et al. (2018) suggest treating the findings with caution given the single study to date and that only one (albeit highly advanced) type of road-based AV and simulator platform were used.

Overall, early public survey data in the context of very limited exposure to vehicles with anything other than rudimentary self-driving capabilities perhaps offer little quantitative guidance concerning how travel decision-making will change. It can also be observed that, should a fully driverless vehicle be achieved, such that no driving ability be required by the user, then the range of transport modes offered to an important minority of UK travellers would be enhanced. It is worth noting that current literature on AV acceptance and usage is currently limited in terms of quantity and not all the evidence presented here is from peer-reviewed literature.

As with all transport high technologies, notably aviation and high-speed rail, there will be technical failures, but those will likely not be influential in the long run provided real demands can be met at affordable prices.

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[9] According to the SAE International Standards of Automation for On-Road Vehicles, there are six levels of automation from Level 0 (no automation) to Level 5 (full automation). Levels 1 and 2 are included in certain vehicles already (e.g. cruise control), while Level 3 allows the vehicle to undertake all driving functions, but with human intervention on request. Level 4 is similar, but does not assume human intervention on request. See: http://www.sae.org/

2.3.2 Shared transport and MAAS

The core of currently emerging MAAS offers is a package of public transport access combined with taxi trips, and access to car sharing and bike sharing facilities.[10] However, for public transport and taxi use, the MAAS offer mainly gives convenience and pricing certainty. For the shared modes, the implications for decision-making are more significant, due to the basis of using vehicles which have traditionally been consumed as owner-user assets. Therefore this section will focus on these modes.

Car sharing[11]

The key objective of car share schemes is to reduce the total number of vehicles on the roads, while still giving members the convenience of access to a car. To date, studies on users of car sharing services have mainly explored user demographics and whether there are differences in the self-reported car ownership, distance travelled and use of other forms of transport, either between an individual's pre- and post-car sharing participation or to a non-car sharing control group (e.g. Becker et al., 2017). Fewer studies have considered factors that are related to participation in car sharing schemes (Prieto et al., 2017).

The studies of car share member behaviour generally show that car use reduces and use of other modes increases after joining a car share scheme (Giesel & Nobis 2016; Clewlow, 2016; Cervero & Tsai, 2004; Martin & Shaheen, 2011). A key economic reason is that a private car represents a considerable sunk investment for most owners, while the 'per trip' costs are often low compared to the alternatives. Therefore car owners tend to use cars for trips for which in some sense they are not the individual and/or the social optimum. Once car access is paid for on a basis much closer to 'per trip', other modes often emerge as a better choice for certain trips. Similarly, as car use is often habitual, it may be the automatic choice when one is owned and parked nearby; the booking process of a car share vehicle encourages deliberation on a wider range of options.

However, car sharing schemes will not be attractive to all car-dependent citizens, as intensive car use will become expensive at typical car share scheme rates. Moreover, most car share schemes still require the vehicle to be returned to a 'home station' bay before the charged period ends, so the option tends not to be attractive for trips requiring a long period at the destination, such as a full day's employment. Beyond such economic factors, however, wanting to maintain car ownership is a barrier to adoption of car sharing and certainly a barrier to reduced car ownership, as ownership is perceived to have a number of advantages. From a practical and legal aspect, ownership of a product entitles the owner to full control over the product, including its usage, accessibility and management (Moeller & Wittkowski, 2010). As such, they are able to use the product as and when they wish, for as long as they

[10] The current global leader is MaaS Global's Whim app, operating in Helsinki, and currently launching in Birmingham (http://maas.global/.)

[11] The term can be the source of some confusion as in the UK the term 'car sharing' previously referred to a form of lift-giving, typically by acquaintances and friends from different households travelling to the same location. This is similar to the practice referred to in the US as 'carpooling' for travel to employment. In transport planning terminology, car sharing now refers to schemes giving exclusive, time-limited access to cars owned by commercial or social enterprises. These schemes were previously referred to in the UK as 'car clubs'.

wish. Such freedom has been found to be major factor in car ownership (see Section 2.1). At the same time, ownership of possessions can be a source of self-esteem, particularly for those with a materialistic orientation (Park & John, 2011). Furthermore, one's possessions may be considered as an extension of the self (Belk, 2007). Again, identity, status and symbolism are crucial aspects of car ownership (see Section 2.1).

Overall, there are aspects of ownership that make it appealing to individuals and may explain why ownership is the currently the predominant and normative form of product and resource usage (Bardhi & Eckhardt, 2012; Belk, 2007). However, while ownership has benefits, there are also drawbacks to ownership, which may reduce individuals' desire to own products. These drawbacks have recently been discussed as the 'burdens of ownership'.

Burdens of ownership

The burdens of ownership are considered to be the risks (obsolescence, incorrect product selection, depreciation of value) and responsibilities (maintenance, repair, the full cost) that are associated with owning an item (Belk, 2007; Moeller & Wittkowski, 2010; Schaefers et al., 2016). It is argued that, for some, a desire to avoid these burdens of ownership encourages use of sharing (access-based) services as an alternative to ownership. In line with this, Moeller and Wittkowski (2010) found that, in a German population sample, a greater desire to avoid responsibility for repair, maintenance, and storage of products (a 'convenience orientation') is positively associated with participants' desire to rent products.

Focusing on the risk perceptions, Schaefers et al. (2016) explored the burden of ownership in relation to cars in a sample of actual users of a car sharing service in the USA. They found that the perceived *financial risk* ('uncertainty regarding the potential financial loss that a purchase decision may result in' p. 571), *performance risk* ('the uncertainty about whether a product will perform as expected' p. 573) and the *social risk* ('the extent to which purchase decisions are believed to be judged by others and may influence one's social standing' p. 573) of owning a car were all positively associated with greater usage of the car sharing service (measured in total minutes used). In turn, greater car sharing usage was positively associated with car ownership reduction (i.e. selling their car). As such, their findings suggest that the greater the perceived burdens of owning a car are, in terms of risks, the more individuals will make use of car sharing services.

Despite concern for the responsibility and risks of ownership increasing sharing intentions and behaviour, in both studies, preferences for ownership were still high (Moeller & Wittkowski, 2010; Schaefers et al., 2016). Indeed, Moeller and Wittkowski (2010) found that the more the ownership of a product, particularly in terms of being able to access their possessions, was seen as important by the participants ('possession importance'), the weaker the participants' intentions to rent goods from a sharing service were. Therefore, there may be a conflict or interaction between the desire to avoid the responsibilities of ownership and the desire to have full control, access and possession of products: and both influence intentions to rent a product. Indeed, this conflict explains the current popularity of lease-ownership of cars and mobile phone contracts covering both handset and network access, which reduce the capital the owner needs to invest in the product, enabling a higher specification model to be bought, and then changed more frequently than would occur with outright purchase. Therefore, for some, leasing may be preferred over shared services as leasing will provide an opportunity to reduce the upfront costs and responsibilities of EVs, while providing the perceived benefits of ownership (Nurhadi et al., 2017). However, evidence for how leasing would influence EV uptake is not apparent within the current literature and would, therefore, require exploration.

Paundra et al. (2017) recently investigated the potential for a desire for ownership to interact with the 'burdens' of costs and convenience of parking on individuals' choice between a shared or owned vehicle with which to complete a journey. They also examined the effect of the vehicle being electric (as opposed to a traditional combustion engine). First, they found that lower price, more convenient parking, and the vehicle being electric are associated with greater intention to select a shared car for their journey. Crucially, they then found that the importance an individual placed on ownership interacted with both cost and vehicle type. For those who are less concerned with ownership, lower cost has a greater influence on intentions to choose a shared vehicle compared to those who are more concerned about ownership. This suggests that those more concerned with ownership are more likely to seek the more expensive private vehicle use as they seek the greater control and access of ownership, while those who are less concerned with ownership primarily seek the cheaper option.

Overcoming barriers to sharing

While perceived responsibilities and risks (or 'burdens') of car ownership may increase willingness to car share, it is also necessary to identify why individuals would avoid car sharing (beyond having a preference for ownership). Hazée et al. (2017) consider this in terms of burdens of access.

Hazée et al. (2017) identify the functional barriers of complexity and reliability and the psychological barriers of contamination and responsibility. Perceiving the sharing service as difficult to access, transact, understand or use and feeling dependent on the reliability of other people or self to be using the service properly, all act as barriers to using a shared service. Furthermore, an awareness of previous, multiple users, a perceived risk of being contaminated by previous users, and a concern for being responsible for looking after something that does not belong to you or being held responsible for previous users' damages, also act as barriers to using shared services. As such, being relieved of the responsibilities when sharing may then be replaced by different responsibilities when sharing as the hirer is responsible to the company and other users, rather than to self. However, some evidence suggests that people drive less recklessly in their own cars compared to a shared car (Bardhi & Eckhardt, 2012), so understanding people's feelings of responsibility towards owned versus shared items and how this influences behaviour, could be important for understanding car sharing adoption and behaviour. It is likely, for example, that car share users will perceive less attachment and responsibility towards a free-floating car share car, that might be expected to be relocated around a city, compared with a station-based car share car, which would typically be allocated to the same bay for periods of months or years, and would mostly be used by scheme members for whom it would be the nearest vehicle to their residences.

While these barriers to the use of shared services were found, Hazée et al. (2017) also identified several strategies that users of car sharing employ to attenuate or overcome these barriers. These included: creating distance from the product by delegating responsibility to the company or ignoring the rules; managing themselves by changing habits, postponing their needs or seeking alternative solutions; elaborating on their reasons for using by comparing to alternatives and remembering advantages; trying to control self and others by reporting misuse or thinking twice before using; and by relating to other users by being accepting and understanding of other users' behaviour, building indirect relationships with other users and informing other users about issues.

Further research needs to be undertaken to understand the situational and psychological factors that lead to some users of shared services being deterred by the barriers and others to overcome the barriers. Hazée et al. (2017) suggest that people may not be willing to engage in the attenuating cognitive processes if doing so is perceived as too difficult, too resource (time, energy) demanding or the barriers are too numerous. Overall, Hazée et al. (2017) point to the 'active, central role of customers in the barrier-attenuating process' (p. 452) as the user must choose to engage in these cognitive processes to overcome a perceived barrier. Identifying the situational and psychological traits of those who are willing to overcome the barriers will be important for future car sharing success.

Predictors of car sharing

Certain factors may predispose individuals to use car sharing services and overcome (or not perceive) the potential barriers. For instance, in South Korea, among users of car sharing services, the intention to keep using is increased by the users having a positive attitude towards car sharing and perceiving it as useful. Furthermore, a positive attitude towards car sharing is increased by users' enjoyment of car sharing, their technological innovativeness (how interested in mobile technologies they are) and, again, the perceived usefulness of car sharing. These three factors were found to be increased by feeling that the car sharing service is reliable, and that use of shared cars is compatible with their lifestyle. Interestingly, costs and concern for privacy do not have a statistically significant effect on intentions to continue use of car sharing (Kim et al., 2017). However, a perceived convenience of car sharing and that it saved time were both positive influences on continued use (Joo, 2017). Similarly, Möhlmann (2015) found that cost savings increased users' satisfaction with car sharing, but had no significant effect on their likelihood of choosing a sharing option again. However, greater belief in the utility of the car sharing (that car sharing fulfils the same needs as owning a car) did lead to a greater likelihood of choosing a car share again. Placing importance on keeping up with the latest products and trends ('trend orientation') is positively associated with participants' desire to rent products (Kim et al., 2017), while a desire to own unique consumer products was found to weaken the negative effect of materialism on willingness to share consumer goods (Akbar et al., 2016). This is argued to be because sharing products facilitates having the latest products or fashion items.

Continued use of car sharing services may depend on users' satisfaction with quite pragmatic characteristics, such as reliability and usefulness within their day-to-day life, but also on affective motives, such as a compatibility with their lifestyle and enjoyment (see Hamari et al., 2014). Furthermore, the compatibility with the users' lifestyle may relate to how using a car sharing service either symbolises or enables their consumption preferences, their desire to be sustainable or their general openness to new experiences. For instance, a greater agreement with being open to new experiences was found to correlate positively with car sharing membership. Furthermore, there was greater agreement with being open to new experiences among the users of the free-floating car sharers (95% agreement) compared to the station-based car sharers (85%), and the non-sharing control group (76%; Becker et al., 2017).

The perceived environmental benefits of car sharing do not appear to have a significant effect on users' intentions to continue using car sharing (Joo, 2017). Likewise, environmental concern is also not related to participants' intentions to rent products (Kim et al., 2017; Möhlmann, 2015). Although pro-environmental motivations were explicit in the pioneering examples of car-sharing clubs in Europe, which were generally established on a voluntary or not-for-profit basis, as car sharing has become commercialised it seems that relationship has weakened, so is not explicit enough for environmentally orientated people to derive any added motivation or positive attitude from it at the moment. For instance, environmental beliefs relating specifically to travel (such as having concerns about the negative effects of car use) do predict more sustainable transport use, including being more multi-modal and car sharing (Tsouros et al., 2017). Similarly, wider sustainability concerns only have a positive influence on intentions to engage in collaborative consumption if the individual possesses a specific concern for environmentally friendly consumption (shared services; Hamari et al., 2014). As such, concerns for the environmental impact of transport behaviour specifically are more likely to influence the selection of more sustainable travel options, such as car sharing, compared to broad environmental concerns.

Virtuous circle

Being involved in a form of car sharing is related to greater interest in other car sharing activities, for instance peer-to-peer and station-based car sharing (Prieto et al., 2017) and a greater likelihood of owning an electric or hybrid vehicle (Clewlow, 2016). While causality is unknown, these findings suggest that users of car sharing and AFVs may enter a 'virtuous circle' of alternative travel means. As such, there are likely to be common, motivational factors and/or benefits from experience.

Peer-to-peer car sharing and ridesharing

Engaging in peer-to-peer car sharing is where ownership is likely to play a different, but equally strong, role, particularly for the owner of the car (or instigator of the journey) that is to be shared. While owning something that others desire access to creates an opportunity for sharing, these same feelings of ownership have been found to discourage sharing behaviour. For instance, the more a possession is considered to be a part of our extended self, to be representative of our identity, then the greater the reluctance to share (Belk, 2007). As with business-to-consumer (B2C) motivations, participation in peer-to-peer (P2P) car sharing has also been found to be driven by economic considerations, such as seeking lower-cost travel (Wilhelms et al., 2017). However, due to the nature of P2P sharing, trust in the community of participants is an important factor in participation (Ballús-Armet et al., 2014). Other motivations may also be important, particularly for the lender, such as feeling gratified by helping others when you are lending your vehicle (Wilhelms et al., 2017).

Literature relating to the behavioural and perceptual aspects of ridesharing is limited in quantity (Nielsen et al., 2015). The focus of ridesharing has also primarily been on commuters ridesharing (‘carpooling’; Neoh, Chipulu & Marshall, 2017). Qualitative research conducted in Denmark relating to ad hoc, acquaintance-based ridesharing, and carpooling, shows that negative perceptions of ridesharing are associated with a lack of available rides (e.g. not reliable), concerns for safety and privacy (e.g. proficiency of the driver), convenience (e.g. uncertainty of luggage capacity), social awkwardness (e.g. potential unpleasantness), and social exclusion (e.g. loss of status for not owning a car, loss of freedom for not having a car). In contrast, positive perceptions of ridesharing are associated with cost savings (relative to individual car driving and public transport), flexibility, comfort and speed (especially in relation to public transport), and the opportunity to socialise and meet new people. It is noteworthy, therefore, that in this study negative perceptions of ridesharing predominantly relate to owning/using a car, while positive perceptions of ridesharing predominantly relate to using public transport. Furthermore, as with car sharing and the ‘burdens of access’, those who advocate ridesharing had strategies for overcoming the perceived negative aspects of ridesharing, such as using a social convention of sitting in the front of the car if wishing to speak or in the back if not.

Shared autonomous vehicles

While AVs may be privately owned, there is a vision that AVs will revolutionise car sharing with shared autonomous vehicles (SAVs) argued to enable the development of autonomous, driverless taxis (Krueger et al., 2016). SAVs with dynamic ride sharing (DRS) take this further by using SAVs to coordinate and serve multiple travellers at the same time. However, SAVs may face resistance from people. For instance, when choosing between different regular car, AV and SAV options, respondents from Israel and America chose the regular car option 44% of the time and even when the SAV option was framed to be hypothetically ‘free’, still only 75% of the respondents were willing to choose the SAV option over the regular car or AV (Haboucha et al., 2017). The service attributes of travel time, waiting time and fares are important for determining SAV use and DRS acceptance (Krueger et al., 2016). In the UK, Clayton et al. (submitted) undertook an online willingness to use and pay experiment contrasting current main mode of urban transport with four self-driving modes (private car, exclusive-use taxi, shared taxi and minibus). Similar to previous studies, under half of participants reported that they would choose to use a self-driving option for one of their current journeys, or in preference to an equivalent human-driven option. Importantly, the shared-taxi option had the smallest proportion of respondents willing to use it, including the minibus. Moreover, the willingness to pay findings showed the greatest value being placed on the exclusive-use driverless taxi option.

While the literature on public preferences for SAVs is currently limited in quantity, it is likely that the perceptual facilitators and barriers to uptake identified in car sharing and AV literature may both apply to the uptake of SAVs, including concerns for safety and complexity, reliability, and contamination. However, it can be discerned that early consumer interest seems more oriented towards private, exclusive travel options, rather than the more efficient, shared solutions that some of the proponents of automation believe the technology might facilitate, through lower operating costs enabling a higher level of service.

Bike sharing

Literature on motivational factors that influence bike sharing is limited (Fishman, 2016). However, as with other forms of transport, a number of studies have found that the belief that shared bikes are convenient is related to their use (Fishman et al., 2013). Saving money has also been found to be a motivator, particularly among lower-income participants (Fishman, 2016). In contrast, the convenience of driving, concerns for safety when riding a bike, the need to wear a helmet and difficulty in registering for the service act as barriers to using bike sharing. Finally, the inconvenience of bike sharing stations is frequently given as one of the main reasons for not using bike sharing (Fishman, 2016).

A summary of the facilitators and barriers for transport decisions discussed in this section is shown in Figure 6.

2.3.3 Summary: facilitators and barriers

Electric vehicles

- The higher upfront purchasing costs (relative to ICEVs), a dissatisfaction with the driving range, battery charging time and a concern for the lack of public charging stations inhibits EV ownership.

- Experience of EVs is an important factor in the adoption of EVs, despite potentially highlighting limitations as well as benefits.

- Congruence between the symbolic attributes of the EV (e.g. environmentally beneficial, technologically innovative) and an individual's self-identity (e.g. environmentalist, innovator) is an important contributor to EV ownership.

- Social influence processes, including conforming to social norms and observing EV usage in one's neighbourhood, are found to increase EV ownership.

Autonomous vehicles

- UK, US and Australian participants express a desire to have automation in their vehicle, but are unwilling to pay extra to have it.

- Safety for both passengers and other road users, fear of a technical failure, an unwillingness to relinquish control of the vehicle, concern about threats from hackers, and concerns relating to the adequacy of AV laws and liability negatively influence intentions to use AVs.

- Trust influences acceptability, adoption and continued use of automation technology and is an important factor in AV acceptance and use.

Shared transport

- Placing greater importance on the benefits of ownership (control, freedom, self-esteem) decreases usage of shared services, while placing greater importance on the risks of ownership (financial, performance and social) increases usage of shared services.

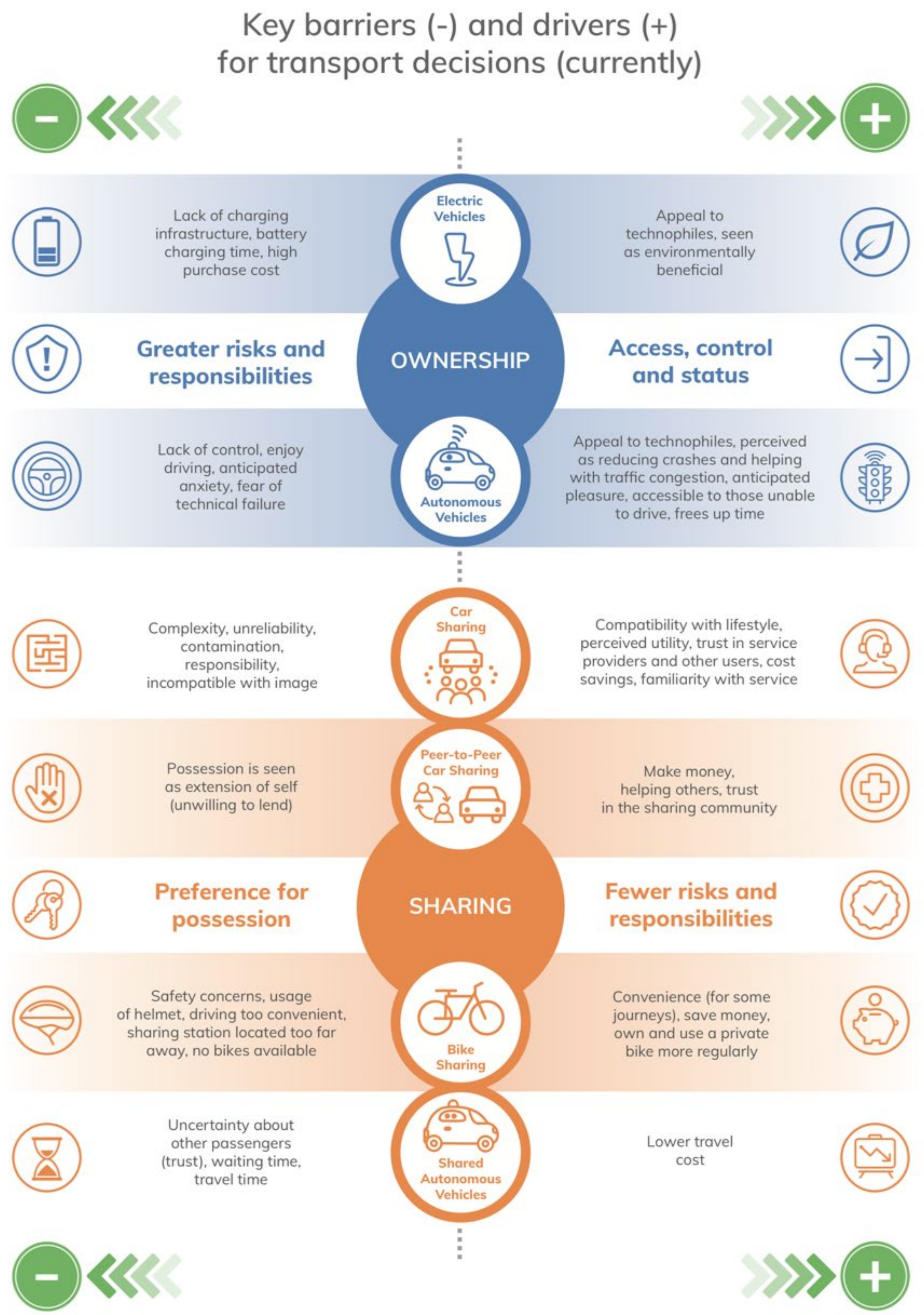
- Perceiving sharing services as difficult to access, transact, understand or use and feeling dependent on the reliability of other people or self to be using the service properly all act as barriers to using shared services.

- Users of shared services have several strategies for overcoming the perceptual barriers, including managing themselves by changing habits, postponing their needs or seeking alternative solutions; elaborating on their reasons for use by comparing to alternatives; and remembering the advantages of the shared service.

- Users' enjoyment of car sharing, their technological innovativeness and the perceived usefulness of the car sharing service contribute towards continued use of a car sharing service.

- Car sharing services being reliable and compatible with lifestyle are also important factors for continued use.

Figure 6: Key barriers (-) and drivers (+) for transport decisions (currently)



2.4 Towards 2040: Projected changes in decision-making and preferences for the transport system

Sections 2.2 and 2.3 discussed the factors that influence transport decision-making and preferences for future travel modes respectively. The following section endeavours to combine these findings with environmental and societal mega-trends and trends in transport use (Section 2.1) to identify:

1. How projected changes to transport modes, technologies and business models up to 2040 will impact transport preferences and choices in the public, and

2. Given the same projected changes, how transport-related attitudes might change or persist.

We draw on a multi-level perspective (MLP) of socio-technical transitions (Geels & Schot, 2007; see Box 1). MLP has frequently been used to conceptualise patterns within socio-technical transitions (Geels, 2011). Here, MLP is used to structure the discussion of the social (consumer) and technical (emerging transport technologies and services) transition to low-carbon mobility into the three levels of function: ‘niche’, ‘regime’ and ‘landscape’. Data from expert interviews is also used to support and develop our viewpoints where appropriate (the interview method can be found in Section 5 and the interview data is appended in Table A5, which will be referred to in the text).

Box 1: Overview of socio-technical transitions theory

Building on Rogers’ (1983) classical theory of innovation as a process of social diffusion initiated by ‘early adopters’, recent research (e.g. Geels, 2005; Geels & Schot, 2007) has sought to expand the focus of innovation studies to encompass not only technological substitution but more profound changes in socio-technical systems (e.g. transport). Central to socio-technical transitions research is the *multi-level perspective* (MLP), an analytical frame for the empirical study of socio-technical innovation. This perspective highlights three functional levels – ‘niche’, ‘regime’ and ‘landscape’ – with increasing structuration and coordination of activities, ranging from individual technologies and grassroots movements to larger-scale social structures and institutions. The *regime* comprises dominant ‘culture, structure, and practices’ (Loorbach, 2007), including routines, regulations, standards, technical systems, sunk investments, and so on, that serve to create stability and cohesion of societal systems (Geels, 2005). Regime actors seek to optimise the current system through incremental change, using the capabilities and resources of dominant players. System innovation, or radical change, is restricted by the dominant rules, structures, and culture. Patterns of behaviour are locked in and result in path dependencies for technological and social development (Geels, 2002).

At the micro level, *niches* have been identified in historical empirical studies of transitions as the typical loci for radical innovation, operating at the periphery of, or outside, the dominant regime. A niche can comprise new technologies, institutions, markets, lifestyles and cultural elements and consists of networks of actors/organisations (e.g, Kemp et al., 1998). The macro level comprises a *landscape* of changing economic, ecological and cultural conditions, in which the regime may be more or less well suited to fulfil its functions. As this landscape changes, the regime may experience stress and is typically slow to adapt, whereas niches more quickly evolve (Geels & Schot, 2007).

Niche development is central in understanding many types of socio-technological transition. Niche-accumulation refers to the gradual growth of niche applications in different niches, before emergence in mass markets (Elzen et al., 2004). For example, electric vehicle niches include industrial vehicles (milk floats, forklifts, etc.) and certain fleets (e.g. pool cars). Niche adoption helps reduce costs and improve functionality of new technologies, as well as increase consumer familiarity with them. Hybridisation is the process of new technologies physically linking up with existing established technologies, enabling a smooth transition from one technological option to the next (e.g. steamships as hybrids between steam and sail technologies; Geels, 2002). Behavioural and institutional change (e.g. new policies, innovative use of technologies including creating new practices/markets) are involved in these niche development processes (Elzen et al., 2004).

2.4.1 Current transport landscape and pressures on the regime

As discussed in Section 2.1, personal mobility using owned ICEVs remains the dominant form of private transport in the UK's current transport regime. Despite the regime being locked in, there are a number of changes in the economic, cultural and ecological systems that are pressurising the current transport regime. These changes can be thought of as the megatrends which create the landscape in which the regime must operate.

There is growing public awareness of and concern for environmental and air quality issues (Eurobarometer, 2008), including car-based air pollution (Smith et al., 2017). As a major contributor to these environmental problems, policies to limit pollution from road transport are being implemented (BEIS, 2017). Furthermore, projected population growth is likely to interact with urbanisation trends which, despite being relatively slow in the UK compared to other countries, are creating more densely populated urban centres and a tendency for urban sprawl. As such, there is an increasing concentration in demand for and use of urban transport (Antrop, 2004). Changes in the UK demographic and economic status are also projected, with people living longer and driving longer, with rising incomes, and a greater number of female drivers, all of which contribute to the demand for transport and particularly cars (see Section 2.1).

2.4.2 Niche dynamics and development

As in the review of sustainable mobility by Nykvist and Whitmarsh (2008), current mobility solutions to the pressures on the transport regime can be considered in three categories: 1) Radical vehicle technologies (e.g. EVs, AVs), 2) Product-to-service shift (MAAS) and 3) Mobility management or substitution (i.e., reducing mobility demand or substituting mobility with ICT; see Figure 7). Here, we discuss how these niche areas may interact with megatrends to influence transport decision-making over the years to 2040. These interactions are also summarised in Table 1.

Radical vehicle technologies

Over the next couple of decades, the shift from traditional internal combustion engine vehicles (ICEVs) to electric vehicles is projected to increase in the UK; this uptake is supported by ambitions to develop EV charging infrastructure (BEIS, 2017). Projections for AVs are more diverse, although 11 companies are claiming they will have highly automated vehicles (at least level 4) by 2020, with some agencies suggesting 90% of cars sold in 2055 will be connected autonomous vehicles (Settler, 2017).

EVs and AVs Up to 2040

If the cost of purchasing EVs becomes relatively affordable to people, battery charging time reduces and/or charging infrastructure becomes more commonplace, then the uptake of EVs is likely to increase (Coffman et al., 2017). This is because the EV will cost less to run, and make use of existing road infrastructure, and so will be able to meet the perceived mobility requirements that an ICEV currently does while causing limited disruption to transport habits (beyond new re-fuelling behaviours). In this sense, EVs are the closest of the niche developments to the regime (represented in Figure 7) and represent broadly a technological substitution for ICEVs (Geels & Schot, 2007).

Political factors and policy are likely to speed up the shift from ICEVs. For instance, the decision by the UK Government to end the sale of pure ICE cars from 2040 will create a cut-off point for new purchases (BEIS, 2017). Those who are able to afford an EV are likely to purchase an EV to seek the perceived benefits of ICEVs (outlined in Section 2.3). Use of finance to either purchase or lease EVs might become more common to reduce upfront costs and/or reduce maintenance and financial responsibilities. However, if costs of EVs remain relatively high or are unaffordable (despite subsidisation and/or finance options), it is likely other transport means will be sought, including MAAS, public transport or active transport – depending on affordability, the built environment, transport infrastructure (including proximity to service) and the users' perceived mobility needs.

As the development of EVs continues, the public will have greater exposure to EV charging stations and/or have more frequent interactions with EV owners than at present. Such exposure and interaction will allow for the social influences (outlined in Section 2.3) to take effect, including exchanging information with others, observing the experiences of others and developing perceptions of the normative behaviour (e.g. for battery charging routines) and what will gain social approval or disproval (Cherchi, 2017; Jansson et al., 2017). As such, EV use may become normalised and/or misconceptions may be challenged.

Uptake of AVs (Level 3 or higher) may also benefit from social influences; however, as noted in Section 2.3, there is likely to be a greater focus on the safety of AV use (for the driver and pedestrians), the experience of not having control over the vehicle, and developing trust in the systems (Körber et al, 2018). Likewise, claimed benefits of AV use (such as the ability to conduct other activities while in the car) will need to be demonstrated and (based on the evidence from acceptance of shared services) these benefits will need to be perceived as being useful and complementary to individuals' lifestyles. Furthermore, for some individuals, it is likely that the benefits of the AV will have to outweigh the removal of the pleasure they get from driving.

Figure 7: Projected changes in decision-making and preferences for the transport system, using the multi-level perspective (adapted from Nykvist & Whitmarsh, 2008)

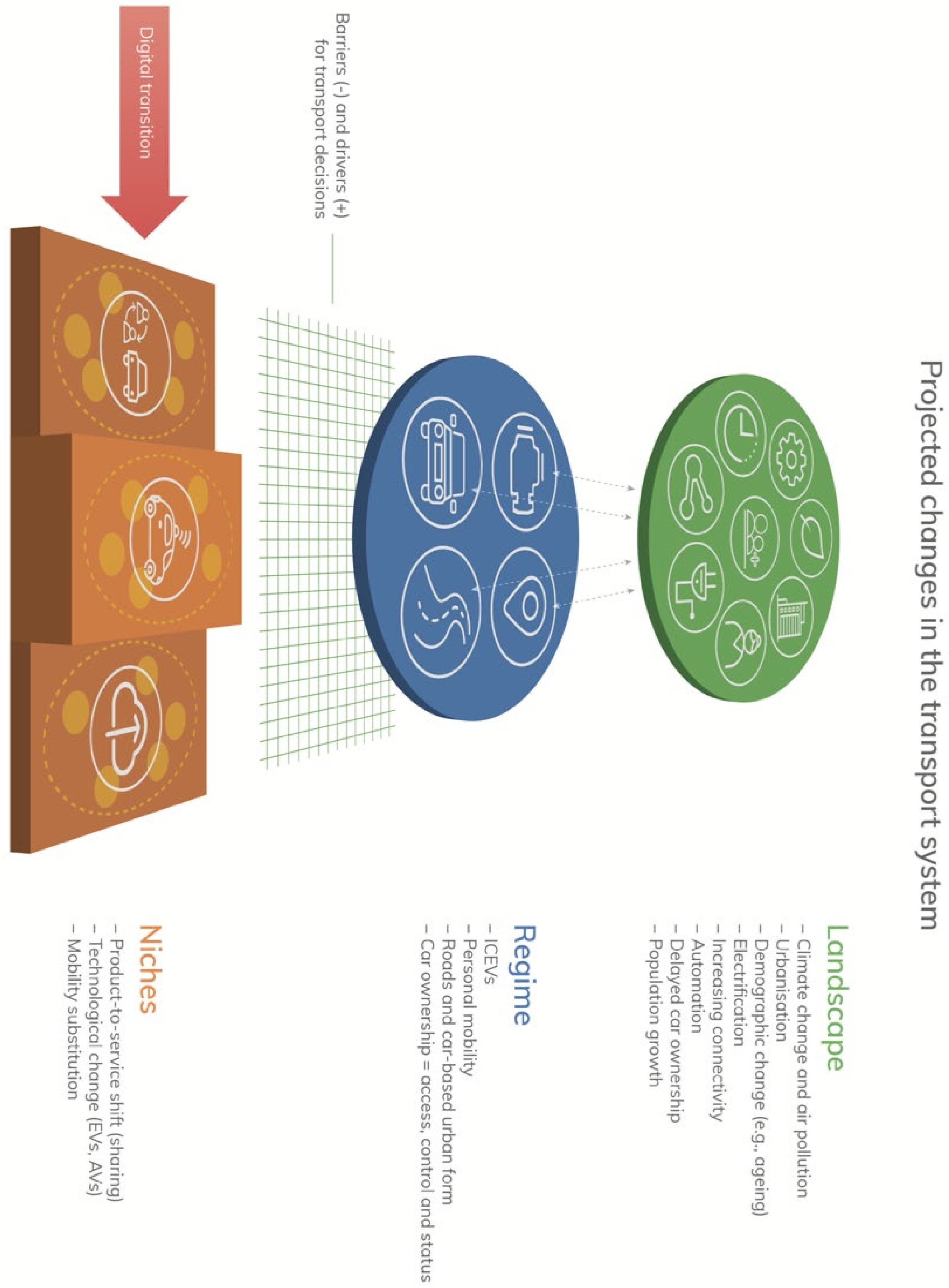


Table 1: Transport decision-making factors by trends and emerging transport modes

	TRANSPORT MODE / TRENDS	Electric vehicles (EV)	Autonomous vehicles (AV)	Shared mobility	Active transport & Mobility substitution
UK population growth	Projected to be over 73.2 million by 2035. (up from ~65 million in 2015)	Once technology and infrastructure developed, EVs likely to match current ICEVs for preference.	Trust and safety concerns may inhibit uptake.	Reducing car ownership, greater convenience through technology and free-floating schemes will increase use.	Interacts with trend of rising obesity levels and greater health-related issues of inactivity. Development of supporting transport infrastructure may encourage a mode switch.
Urbanisation	81.5% of UK population lived in urban areas in 2011.	Greater congestion (loss of valued time), limitations on parking, limited access to private charging (transport infrastructure) and convenient availability of public transport and MAAS decrease uptake/use.	Congestion argued to ease as a result of efficient, coordinated driving, but if overall number of vehicles remains high or increases, congestion may still be an issue.	Greater burdens of ownership (pressure on parking, etc.) and greater prevalence of MAAS (transport infrastructure) in urban centres may lead to greater use of shared mobility and decreased car ownership.	Greater cycling infrastructure promoting cycle behaviour (transport infrastructure). Greater street density and accessibility of amenities, so higher probability of walking (built environment effects).
Demographic changes	Projected increase in population over 65. Greater proportion of female drivers.	Interacts with trends of preference for rural living in older demographics and a slower development of EV infrastructure in rural areas. May create slower uptake in certain demographics. A greater number of female drivers may contribute to an overall demand for transport.	Uptake by elderly and/or non-drivers. Will enable people to use personal mobility even when ageing.	Interacts with trends of preference for rural living in older demographics and younger people using MAAS. May increase the divide in demographics of MAAS users.	Active transport may be less available for older demographics. Offers low-cost transport mode for those unable to afford (or unwilling to buy) personal or shared mobility.

Peak car	Contrary to projections, some indications that car travel per person has plateaued in UK.	Affordability of EVs may be a barrier even as costs come down, particularly for younger people. Habits may develop for MAAS use and so car (ownership) dependency may diminish or not develop.	Affordability of AVs may be a barrier even as costs come down, particularly for younger people.	Status of ownership may decline and social norms for use of shared mobility develop.	If built environment and transport infrastructure is present, use of active transport may reduce and/or delay car ownership. Shared bikes (along with infrastructure changes) may disrupt formed transport habits.
Increasing digital connectivity	Smartphone ownership is increasing, high-speed internet access is increasing.	EVs may become incrementally digitally enhanced as precursors to AVs.	Trust in technology systems may inhibit use of CAVs.	Greater confidence and ease of accessing MAAS using digital technology.	Telecommuting may reduce the need for longer journeys typically completed using non-active transport.
Environmental sustainability	Targets for low-carbon transport. Greater resource constraints.	Materials needed for construction are finite + greater embodied carbon of EVs will mean slower turnover of car ownership. Those seeking less environmentally impactful transport, may seek EVs as an alternative.	Congestion argued to ease as a result of efficient, coordinated driving, but if overall number of vehicles remains high or increases, sustainability may remain an issue.	May lead to reduced car ownership and use, which will have a positive impact on air pollution and resource use. May also lead to a shift from public transport to personal mobility, which may create bigger, negative environmental impacts.	Reduces dependency on all forms of cars, which benefits the environment and health. Seeking to reduce environmental impact and/or be active might increase cycling uptake, but lack of supporting infrastructure will constrain.

New social and cultural norms may develop around the use of ICEVs. For instance, given the increasing public concern for the environment and rising air pollution, if EV adoption reaches an increased level of normality, then a negative image of ICEVs and ICEV drivers may develop, which may pressure ICEV drivers to seek alternative transport (this might be akin to the way that changing cultural norms due to greater awareness of the health risks and subsequent banning of indoor smoking has led to a more negative image of cigarette smoking and reduced numbers of people smoking; Stuber et al., 2008). Use of private, high-polluting vehicles may become less socially acceptable, particularly in urban centres where air pollution is highest and alternative travel modes are most accessible. This social disapproval may further increase rate of EV adoption (or indeed, active forms of travel); however, consideration must be given to those who are unable to afford EVs and so may be subject to unavoidable stigmatisation as a result of the changed transport norms (Bell et al., 2010).

Impact of AVs and EVs

The potential for AVs to be used by people who are not (or no longer) able to drive has a large implication for the ageing population. AVs offer the possibility for elderly people to keep using personal mobility. One interviewee pointed to the positive attitudes from participants in a UK trial where elderly people were given the chance to experience an AV (see 4.b. in Table A5) and suggested that the prevailing view that AVs will mainly be of interest to younger people should be challenged. Indeed, this interviewee emphasised an openness to new experience as being important for AV uptake. There could be a growing uptake of AVs toward 2040 as the technology is developed and if the current generation wishes to maintain personal mobility. As such, this may sustain the number of vehicles on the road for each generation as use of personal mobility is extended into older age. However, one interviewee pointed to the danger that an increase in AV use or the expectancy that elderly people will make use of AVs, could lead to developers building retirement homes further from the city centre. This would then generate or exacerbate lock-in effects (akin to the car lock-in described in Section 2.1.) where personal mobility (from AVs or other driving assistive technologies) is an expected option for elderly people to be able to access services and amenities in towns and cities (alongside relatives, public transport or paid for driving services; Shergold et al., 2015).

The environmental impacts of EV (and AV) production have the potential to impact on consumer behaviour. One interviewee pointed to the challenges of continued EV production when the materials and resources used in their construction are finite and must be continually sourced or substituted. This interviewee also pointed to the greater embedded carbon of EVs compared to ICEVs. As a consequence, the interviewee suggested a need for vehicle manufacturers to change their business models and for EV owners to wait longer before exchanging their vehicle (see 6.a in Table A5). As previously mentioned, there is evidence that some consumers raise concerns about the electricity of EVs being from renewable sources (Degirmenci and Breitner, 2017); therefore, for those seeking a truly more environmentally friendly alternative to using an ICEV, issues of material use and embedded carbon are likely to further reduce their intentions to own an EV. Not exchanging an ‘old’ EV for a newer EV may also be a particularly difficult shift for individuals who currently enjoy having the latest technologies or enjoy and derive status from regularly purchasing new cars.

It was felt by interviewees that owning EVs and AVs still offers personal mobility in much the same way as ICEVs and so they will not fundamentally change the transport decision-making process. Therefore, a majority uptake of these vehicles is likely to suffer from the same pressures as the current transport regime in terms of congestion, health and environmental sustainability. Indeed, these pressures may increase to 2040 due to increasing numbers of elderly and female drivers and overall rising travel demand. Accordingly, some interviewees felt that EVs and AVs are limited solutions to transport challenges (3.b in Table A5).

Product-to-service shift (MAAS)

The product-to-service shift offered by MAAS is perhaps a more radical disruption to the transport regime than EVs or AVs from the perspective of transport decision-making. Projections of MAAS are limited (Enoch, 2017); however, supporting technological trends, such as smart phone ownership and high-speed internet connectivity are projected to continue rising (Poushter, 2016).

MAAS up to 2040

Currently, evidence suggests that it is younger people living in urban centres who are utilising MAAS, perhaps due to inability to afford ownership, although other beliefs regarding risk and responsibilities may be influential. As such, projecting the uptake of MAAS up to 2040 will require understanding whether participation in MAAS is due to individuals' life circumstances or their values and beliefs. While usage due to values and beliefs might lead to a sustained use of MAAS, changes to an individual's lifestyle may alter their willingness to use shared services (2.b in Table A5). As highlighted in Section 2.3, lifestyle compatibility is important for continued use of shared car services. Further research into the motivational factors of shared vehicle use will need to be conducted to determine what psychological factors underlie the use of shared services and reduced car ownership. It will be important to establish how they develop over time to see if usage is maintained through changes in life circumstances (Klein & Smart, 2017).

Sustaining use of MAAS and shared services usage throughout changes in lifestyle may benefit from the experience of using the necessary technology (i.e. smart phones, apps; cf. Geels, 2005) and experience of using MAAS to meet perceived mobility needs. Such experience may develop habits, while limiting the development of car dependency.

Alongside the discussions of peak car, one interviewee pointed to a decline in the status associated with car ownership and the potential for the decline to continue with subsequent generations (see 1.c in Table A5). Given the established importance of status in vehicle ownership (see Section 2.3.2), a reduction in the perceived social reward for owning a vehicle may reduce individuals' concern for owning a vehicle and/or reduce the expectation of a negative judgement for not owning a vehicle. Again, however, further research will need to establish the existence of this trend, its longevity through changes in life circumstances, and its implications for travel behaviour.

An important issue for all shared services is the norms surrounding their appropriate use. As discussed in Section 2.4, a perceived barrier to using shared services is often the knowledge that there have been other users in the car and a concern for how they may have treated the car. One interviewee highlighted this as a particular problem for free-floating shared vehicles in France, which were treated so poorly by some users that the vehicles became too unpleasant and unusable for other users (see 2.d in Table A5). Likewise, free-floating (or 'dockless') bike share schemes globally have suffered from problems of irresponsible discarding of the bikes or of vandalism.[12] Therefore, as with all shared goods, such as parks and city centres,

[12] https://www.theguardian.com/politics/2017/nov/05/why-we-cant-have-nice-things-dockless-bikes-and-the-tragedy-of-the-commons

social norms will need to develop (and be promoted) to regulate and discourage damaging behaviour which could prevent or dissuade others from using the shared vehicle (Cialdini & Goldstein, 2004). This issue will be particularly important for shared autonomous vehicles (SAVs) where individuals might be able to use the vehicle on a completely ad hoc, anonymous basis and so avoid culpability for their actions.

2.4.3 Summary

- Evidence from expert interviews and the literature review were used in conjunction to discuss aspects of the future of mobility.

- The ageing population, electrification and digitalisation are pressurising the current transport regime.

- Solutions can be categorised as either: radical vehicle technologies (e.g. EVs, AVs), product-to-service shift (MAAS) and mobility management or substitution (i.e., reducing mobility demand or substituting mobility with ICT).

EVs and AVs

- If the cost of purchasing EVs becomes relatively affordable to people, battery charging time reduces and/or charging infrastructure becomes more commonplace, then the uptake of EVs is likely to increase as they offer a near substitution for ICEVs.

- If costs of EVs remain relatively high or are unaffordable (despite subsidisation), it is likely that other transport means will be sought (once ICEVs are no longer available or financially viable) including MAAS, public transport or active transport – depending on their relative affordability, the built environment, transport infrastructure (including proximity to service) and individuals' perceived mobility needs.

- EV use may become normalised and/or misconceptions may be challenged as greater exposure and interaction to EVs and EV users will allow for social influences (outlined in Section 2.3) to take effect, including exchanging information with others, observing the experiences of others and developing perceptions of normative behaviour.

- Uptake of AVs (Level 3 automation or higher) may also benefit from social influences; however, there is likely to be a greater focus on the safety of AV use (for the driver and pedestrians), the experience of not having control over the vehicle, and developing trust in the systems.

Product-to-service shift (MAAS)

- It is important to understand whether participation in MAAS by younger individuals is due to their current life circumstances (and therefore subject to change) or their values and beliefs (and therefore more stable).

- A decline in deriving status from car ownership could support a greater uptake of leasing or shared services. However, further research is needed to establish the existence of this trend, its longevity through changes in life circumstances, and its implications for travel behaviour.

- As with all shared goods, social norms will need to develop (and be promoted) to regulate and discourage damaging behaviour which could prevent or dissuade others from using the shared vehicle.

- Access to shared vehicles, on the one hand, can contribute to delayed or deterred car ownership and reduced travel, but on the other hand it can encourage greater car usage in place of more efficient travel modes, such as public transport or active transport.

Mobility management and substitution

- Infrastructure that supports active transport, such as foot/cycle paths, will encourage active travel. Therefore, the development of accessible and/or walkable cities is likely to be necessary to promote active transport modes, particularly in light of continued urbanisation and population growth.

- Targeting ‘windows of opportunity’, such as when moving house, may mean people are more receptive to new travel mode information as previous travel habits are disrupted and new transport decisions are being made.

- Factors such as facilitating infrastructure, information, experience and social influences are likely to be needed in combination to affect transport behaviour change.

Impacts of car sharing on car use and ownership

As discussed in Section 2.3.2, there is early evidence that use of station-based car sharing leads to reduced vehicle travel (Giesel & Nobis 2016; Clewlow, 2016; Cervero & Tsai, 2004; Martin & Shaheen, 2011), a reduced need for parking spaces (Shaheen et al., 2010) and greater promotion of public transportation use and active modes of travel (Sioui et al., 2013). This is because people integrate their use of the shared car with other modes of transport. There is evidence that participation in car sharing not only reduces travel distances, but perhaps also reduces or deters ownership of cars. For instance, not only was ownership found to be lower, but there is some evidence that participation in car sharing schemes deters individuals from purchasing cars (Nijland & van Meerkerk, 2017; Le Vine & Polak, 2017). However, station-based car sharing faces particular uptake challenges due to the importance of autonomy and proximity of stations that influence transport decisions (see section 2.2.1 and 2.2.2). The fixed location of the station will require people to travel to the station, and the greater the distance the less willing they may be to travel that distance. In addition, even if digital technology continues to make it more convenient, advanced booking and the potential for unavailability may still threaten autonomy.

While free-floating car sharing and SAVs may solve the issue of proximity and autonomy, there is concern that, due to its spontaneous convenience, free-floating car sharing and SAVs might encourage the use of cars for journeys that were previously made using the more environmentally friendly options of public transport, cycling or walking, or even lead to journeys that otherwise would not have been made (Firnkhorn, 2012). For instance, free-floating car-sharing users were found to decrease their use of public transportation and reduce their use of bicycles or walking (Firnkorn, 2012; Le Vine et al., 2014), whilst Nijland and van Meerkerk (2017) found that free-floating car sharing was used to replace train journeys. As such, car sharing may, on the one hand, contribute to delayed or deterred car ownership and travel, but on the other hand, encourage greater car usage. Understanding how people's travel habits adapt to meet their perceived travel needs in response to the availability and use of car sharing will be important for anticipating car travel behaviour (either shared or owned).

Mobility management & substitution

A trend that has yet to be mentioned is rising obesity levels and related physical inactivity in the UK (ONS, 2013). As recognised in the UK Government's 'Cycling and Walking Investment Strategy', encouraging active transport could have health benefits by increasing exercise and reducing air pollution (Department for Transport, 2017). Currently, active forms or transport, such as walking or cycling are predicted to remain stable towards 2040 without policy intervention (Harvey & Guo, 2017).

As discussed in Section 2.2.2, the built environment and transportation have large implications on travel decision-making, particularly walking and public transport use (Jahanshahi & Jin, 2016). This was further supported by one interviewee who argued that choice of active transport modes is most heavily influenced by the availability of facilitating infrastructure (see 5.b in Table A5). Considering that the convenience of the car is perceived to be a barrier to greater uptake of active transport options, then infrastructure developments that make driving (at least temporarily) easier will inhibit the uptake of active transport. Conversely, infrastructure that supports active transport, such as foot/cycle paths, has been found to encourage active travel (see 'Transport infrastructure' in Section 2.2.2). Therefore, the development of accessible and/or walkable cities is likely to be necessary, particularly in light of continued urbanisation and population growth (Hoehner et al., 2005; Nordh et al., 2017).

Self-imposed constraints on travel choice come through habits and perceived behavioural control. Once travel habits are formed, they are powerful predictors of transport behaviour and have a negative impact on people's perceived control over their transport choices (thereby reducing their intentions to change their current mode; Chen & Chao, 2011) and on information seeking for alternative travel modes. This is particularly true if the habitual travel mode is the car (Şimşekoğlu, Nordfjærn & Rundmo, 2015). Targeting windows of opportunity, such as when moving house, may mean people are more receptive to new travel mode information as previous habits are disrupted (Walker et al., 2015). As such, when moving house or starting a new job, information about the nearby public transport options and routes for cycling or walking could be provided. Furthermore, as time taken for and satisfaction with a journey is partly a matter of perception, there may also be potential to challenge assumptions about how much time alternative travel modes take (versus cars) either through direct, personal experience or from learning through social influences. Such factors as facilitating infrastructure, information, experience and social influences are likely to be needed in combination to affect transport behaviour change.

Opportunities to reduce overall travel demand by use of telecommunications may increase in the years to 2040 (discussed in Section 2.2.4). Reflecting the literature, one interviewee discussed the possibility for commuting patterns to change (7.a in Table A5). A reduction or shift in commuting times may complement and support the uptake of MAAS, as reducing and/or shifting the number of travellers will decrease the number of cars needed in the fleet to cope with peak demand (Peer, Knockaert & Verhoef, 2014. Furthermore, commuting is frequently perceived as a heavily constrained journey and a major factor in individuals' perceived mobility needs (Abrahamse et al., 2009). Therefore, greater flexibility in time and/or location for certain occupations may remove this mobility constraint and enable greater flexibility in travel decision-making.

3 Conclusion

With a focus on domestic, land-based transport modes for non-commercial use, this review has discussed the main factors influencing (a) car choice and (b) transport modal choice, as well as perceptions and (potential) adoption of new transport technologies and modes (e.g. AVs, EVs, MAAS). We now draw out implications for decision-making today and identify research needs.

3.1 Implications for decision-making today

The evidence summarised in this review suggests that transitions to EVs, AVs and MAAS (as well as, potentially, mobility substitution) will be disruptive to different degrees for lifestyles, cultural norms, business models and socio-technical systems more broadly. Adoption of EVs is likely to face fewer barriers than adoption of AVs, while mobility sharing and mobility substitution are likely to be more challenging for the current societal 'lock-in' to car ownership and use.

3.1.1 Electric vehicles

Unlike straight technological substitution (e.g. cathode-ray tube to flat screen televisions), EVs require new (charging) infrastructure and patterns of charging and driving behaviours (as well as new vehicle designs). While cost and functionality for EVs are increasingly attractive, given the Government's policy objective of replacing ICEVs with EVs by 2040 (to address urban air quality, etc.), widespread adoption of EVs will require support for charging infrastructure, as well as incentives for niche adoption (e.g. fleet operators) in order to increase public familiarity with and acceptance of these vehicles. Marketing of EVs should focus on the high-tech and clean credentials of EVs, which are known to be facilitators of adoption. Diffusion processes mean that once early adopters demonstrate and make EVs normative, more consumers are likely to follow suit.

3.1.2 Autonomous vehicles

Less is known about how the public will respond to AVs than EVs, though the evidence suggests considerable heterogeneity (while many innovators and technophiles are enthusiastic, others are more anxious or wary) and likely gradual acceptance as consumers habituate to more elements of automation in vehicles.

Ongoing research indicates that trying to communicate levels of autonomy to non-specialist audiences is not helpful; rather, it is better to talk in terms of specific human and machine capabilities. Were Government to keep supporting a transition to AVs, there is an urgent need for more research on how AVs may reconfigure lifestyles and patterns of work, and have consequences (both positive and negative) for congestion, health, emissions and the broader economy. For example, while AVs may be positive in terms of social inclusion (e.g. improving access to services and employment opportunities for disabled and older groups), road safety, and economic benefits (e.g. improving productivity and avoiding business costs associated with congestion), it may increase the volume of traffic on roads and reduce uptake of active travel. The implications for the well-being of the UK population are therefore unclear.

3.1.3 Mobility services and substitution

Evidence suggests that the current trend particularly among younger groups to avoid car ownership may continue, which would help Government in achieving its carbon emissions targets. A recent study (Chatterjee et al., 2018) on young people showed that young people are less likely to obtain a driving licence and, if young people later to go onto obtain their driving licence, they tend to drive less, part of a sustained trend since the early 1990s. This study also indicated that the travel behaviour of the next generation will be similar to those born in the 1980s and 1990s and that these trends will continue unless there is a sudden reduction in unemployment of young people, of them going onto higher education, or of car and housing costs coming down.

However, it is also possible that car ownership is merely being delayed by some younger people, due to lifecycle factors (e.g. having children predicting car ownership). Further, physical and cultural lock-in to car ownership and use, along with growing demand for transport (due to demographic and economic trends) will most likely mitigate or outweigh 'peak car' effects on demand. Urban design and (materialist) social norms reinforce car dependence. Indeed, a key finding from our review is that transport behaviour is often constrained by external factors or by personal habits. Indeed, external influences (e.g. design of the built environment) motivate and constrain much travel behaviour. At the same time, these constraints are experienced subjectively, such that some individuals may be prepared to walk or cycle where others would not. Consistent with environmental psychological models of behaviour (e.g. Lewin, 1939), individuals' motivations to use different modes will be a product of both internal (e.g. attitudes, perceived control) and external (e.g. road layout, distance) factors.

Consequently, interventions to change behaviour will need to target both individual factors (e.g. via information) and structural ones (e.g. via planning). Were Government to provide more support for mobility substitution and sharing by prioritising low-carbon and active travel alternatives to car use and car share schemes in planning decision-making, this would help reduce the degree of (perceived and actual) lock-in to car dependence and ultimately improve the well-being of the UK population. In addition to these changes to infrastructure and service provision, promoting the benefits of car/bike sharing, such as lower costs and burden of ownership (e.g. maintenance, parking), would help facilitate a cultural shift towards mobility as a service. Furthermore, challenging misperceptions about public or shared modes by encouraging car users to try these alternatives (which may be quicker or more attractive than assumed) would also help reduce car attachment. Substituting mobility with ICT alternatives (e.g. teleworking, online shopping) to address current transport problems (emissions, congestion, accidents, etc.) will equally require a combination of informational and infrastructural approaches to remove the range of technological, organisational and psychological barriers.

3.2 Research gaps and future directions

- More research is needed on how people will use AVs (e.g. activities undertaken within the vehicle; where the empty vehicle will go) and consequences for lifestyles and society more broadly.

- A further major uncertainty in mobility research is understanding individuals' willingness to share under different scenarios. There are currently various barriers and drivers to car and bike sharing, but little experimental research to determine which scheme features are likely to be most effective in attracting and retaining users.

- There is growing evidence to suggest that early life transport behaviour is sustained and that travel behaviour of the next generation will be similar to those born in the 1980s and 1990s, and there is a need to explore how 'peak car' relates to life stage; for example whether the younger generation is merely delaying vehicle ownership until starting a family and/or having sufficient income. This will help elucidate whether projections for widespread adoption of MAAS and mobility substitution are realistic.

- There is a need to ensure that transport models and forecasts are behaviourally realistic, for example including a range of conscious and unconscious influences on modal and vehicle choice (e.g. social influences on adoption of EVs and AVs; role of habits in modal choice).

- While beyond the scope of this review, the impact of megatrends on consumer air travel as well as the indirect impacts of consumer behaviour on commercial transport (e.g. delivery vehicles, cargo ships) would be of interest to consider given their large contribution to greenhouse gas emissions.

4 References

Abe, G., Sato, K. and Itoh, M. (2015). Drivers trust in automated driving when passing other traffic objects. In *IEEE Systems, Man, and Cybernetics* (SMC) International Conference, pp. 897–902.

Abrahamse, W., Steg, L., Gifford, R. and Vlek, C. (2009). Factors influencing car use for commuting and the intention to reduce it: A question of self-interest or morality? *Transportation Research Part F: Traffic Psychology and Behaviour*, 12(4), 317–324.

Abrantes, P. A. and Wardman, M. R. (2011). Meta-analysis of UK values of travel time: An update. *Transportation Research Part A: Policy and Practice*, 45(1), 1–17.

Adams, E. J., Goodman, A., Sahlqvist, S., Bull, F. C. and Ogilvie, D. (2013). Correlates of walking and cycling for transport and recreation: factor structure, reliability and behavioural associations of the perceptions of the environment in the neighbourhood scale (PENS). *International journal of behavioral nutrition and physical activity*, 10(1), 87.

Aditjandra, P. T., Cao, X. J. and Mulley, C. (2012). Understanding neighbourhood design impact on travel behaviour: An application of structural equations model to British metropolitan data. *Transportation research part A: policy and practice*, 46(1), 22–32.

Aditjandra, P. T., Mulley, C. and Nelson, J. D. (2013). The influence of neighbourhood design on travel behaviour: Empirical evidence from North East England. *Transport Policy*, 26, 54–65.

Akbar, P., Mai, R. and Hoffmann, S. (2016). When do materialistic consumers join commercial sharing systems. *Journal of Business Research*, 69(10), 4215–4224.

Aldred, R. and Jungnickel, K. (2014). Why culture matters for transport policy: the case of cycling in the UK. *Journal of Transport Geography*, 34, 78–87.

Anable, J. (2005). 'Complacent Car Addicts' or 'Aspiring Environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport Policy*, 12, 65–78.

Anderson, S. T., Kellogg, R. and Sallee, J. M. (2013). What do consumers believe about future gasoline prices? *Journal of Environmental Economics and Management*, 66(3), 383–403.

Andwari, A.M., Pesiridis, A., Rajoo, S., Martinez-Botas, R. and Esfahanian, V. (2017). A review of Battery Electric Vehicle technology and readiness levels. *Renewable and Sustainable Energy Reviews*, 78, 414–430.

Antrop, M. (2004). Landscape change and the urbanization process in Europe. *Landscape and urban planning*, 67(1), 9–26.

Arnott, B., Rehackova, L., Errington, L., Sniehotta, F. F., Roberts, J. and Araujo-Soares, V. (2014). Efficacy of behavioural interventions for transport behaviour change: systematic review, meta-analysis and intervention coding. *International journal of behavioral nutrition and physical activity*, 11(1), 133.

Axsen, J., Bailey, J. and Castro, M. A. (2015). Preference and lifestyle heterogeneity among potential plug-in electric vehicle buyers. *Energy Economics*, 50, 190–201.

Axsen, J., Goldberg, S. and Bailey, J. (2016). How might potential future plug-in electric vehicle buyers differ from current 'Pioneer' owners? *Transportation Research Part D: Transport and Environment*, 47, 357–370.

Ballús-Armet, I., Shaheen, S., Clonts, K. and Weinzimmer, D. (2014). Peer-to-peer carsharing: Exploring public perception and market characteristics in the San Francisco Bay area, California. *Transportation Research Record: Journal of the Transportation Research Board* (2416), 27–36.

Baltas, G. and Saridakis, C. (2013). An empirical investigation of the impact of behavioural and psychographic consumer characteristics on car preferences: An integrated model of car type choice. *Transportation Research Part A: Policy and Practice*, 54, 92–110.

Bansal, P., Kockelman, K. M. and Singh, A. (2016). Assessing public opinions of and interest in new vehicle technologies: an Austin perspective. *Transportation Research Part C: Emerging Technologies*, 67, 1–14.

Bardhi, F. and Eckhardt, G. M. (2012). Access-based consumption: The case of car sharing. *Journal of consumer research*, 39(4), 881–898.

Bargh, J. (1989). Conditional Automaticity: Varieties of automatic influence in social perception and cognition. In J. Uleman & J. Bargh (eds.) *Unintended Thought* (pp. 3–51). New York: Guildford Press.

Barr, S. and Prillwitz, J. (2014). A smarter choice? Exploring the behaviour change agenda for environmentally sustainable mobility. *Environment and Planning C: Government & Policy*, 32(1), 1–19.

Bartels, J. and Reinders, M.J. (2011). Consumer innovativeness and its correlates: A propositional inventory for future research. *Journal of Business Research*, 64(6), 601–609.

Barth, M., Jugert, P. and Fritsche, I. (2016). Still underdetected – Social norms and collective efficacy predict the acceptance of electric vehicles in Germany. *Transportation research part F: traffic psychology and behaviour*, 37, 64–77.

Bastian, A., Börjesson, M. and Eliasson, J. (2016). Explaining ‘peak car’ with economic variables. *Transportation Research Part A: Policy and Practice*, 88, 236–250.

Becker, H., Ciari, F. and Axhausen, K.W. (2017). Comparing car-sharing schemes in Switzerland: User groups and usage patterns. *Transportation Research Part A: Policy and Practice*, 97, 17–29.

Belk, R., 2007. Why not share rather than own?. *The Annals of the American Academy of Political and Social Science*, 611(1), 126–140.

Bell, K., Salmon, A., Bowers, M., Bell, J. and McCullough, L. (2010). Smoking, stigma and tobacco ‘denormalization’: Further reflections on the use of stigma as a public health tool. A commentary on Social Science & Medicine’s Stigma, Prejudice, Discrimination and Health Special Issue (67: 3*). Social science & medicine*, 70(6), 795–799.

Boarnet, M. G. and Hsu, H. P. (2015). The gender gap in non-work travel: The relative roles of income earning potential and land use. *Journal of Urban Economics*, 86, 111–127.

Bonett, D. G. (2007). Transforming odds ratios into correlations for meta-analytic research. *American Psychologist*, 62(3), 254–255.

Bornioli, A., Parkhurst, G. and Morgan, P. (2018).The psychological wellbeing benefits of place engagement during walking in urban environments: A qualitative photo-elicitation study. *Health & Place*, 53. pp. 228-236. ISSN 1353-8292 Available from: http://eprints.uwe.ac.uk/37592

Burgess, M., King, N., Harris, M. and Lewis, E. (2013). Electric vehicle drivers’ reported interactions with the public: Driving stereotype change? *Transportation research part F: traffic psychology and behaviour*, 17, 33–44.

Busch-Geertsema, A. and Lanzendorf, M. (2015). Mode Decisions and Context Change–What About the Attitudes? A Conceptual Framework. In *Sustainable Urban Transport* (pp. 23–42). Emerald Group Publishing Limited.

Cairns, S., Sloman, L., Newson, C., Anable, J., Kirkbride, A. and Goodwin, P. (2004). *Smarter choices-changing the way we travel. Final report of the research project: The influence of soft factor interventions on travel demand*. Research Report, Department of Transport, London. Available at: http://discovery.ucl.ac.uk/1224/1/1224.pdf Retrieved 22/11/17.

Carley, S., Krause, R. M., Lane, B. W. and Graham, J. D. (2013). Intent to purchase a plug-in electric vehicle: A survey of early impressions in large US cities. *Transportation Research Part D: Transport and Environment*, 18, 39–45.

Carmona, M. (2009). The Isle of Dogs: Four development waves, five planning models, twelve plans, thirty-five years, and a renaissance… of sorts. *Progress in Planning*, 71(3), 87–151.

Carmona, M. (2015). London's local high streets: The problems, potential and complexities of mixed street corridors. *Progress in Planning*, 100, 1–84.

Cervero, R. and Tsai, Y. (2004). City CarShare in San Francisco, California: second-year travel demand and car ownership impacts. *Transportation Research Record: Journal of the Transportation Research Board* (1887), 117–127.

Chatterjee, K., Goodwin, P., Schwanen, T., Clark, B., Jain, J., Melia, S., Middleton, J., Plyushteva, A., Ricci, M., Santos, G. and Stokes, G. (2018). *Young People's Travel – What's Changed and Why? Review and Analysis*. Report to Department for Transport. UWE Bristol, UK.

Chen, C.F. and Chao, W.H. (2011). Habitual or reasoned? Using the theory of planned behavior, technology acceptance model, and habit to examine switching intentions toward public transit. *Transportation Research Part F: Traffic Psychology and Behaviour*, 14(2), 128–137.

Cherchi, E. (2017). A stated choice experiment to measure the effect of informational and normative conformity in the preference for electric vehicles. *Transportation Research Part A: Policy and Practice*, 100, 88–104.

Cherrett, T., Dickinson, J., McLeod, F., Sit, J., Bailey, G. and Whittle, G. (2017). Logistics impacts of student online shopping – Evaluating delivery consolidation to halls of residence. *Transportation Research Part C: Emerging Technologies*, 78, 111–128.

Choi, J. K. and Ji, Y. G. (2015). Investigating the importance of trust on adopting an autonomous vehicle. *International Journal of Human–Computer Interaction*, 31(10), 692–702.

Cialdini, R.B. and Goldstein, N.J. (2004). Social influence: Compliance and conformity. *Annu. Rev. Psychol.*, 55, 591–621.

Clark, B., Chatterjee, K. and Melia, S. (2016a). Changes to commute mode: The role of life events, spatial context and environmental attitude. *Transportation Research Part A: Policy and Practice*, 89, 89–105.

Clark, B., Chatterjee, K. and Melia, S. (2016b). Changes in level of household car ownership: the role of life events and spatial context. *Transportation*, 43(4), 565-599.

Clark, B., Lyons, G. and Chatterjee, K. (2016). Understanding the process that gives rise to household car ownership level changes. *Journal of Transport* Geography, 55, 110–120.

Clark, B., Parkhurst, G. and Ricci, M. (2016) *Understanding the socioeconomic adoption scenarios for autonomous vehicles: A literature review*. Project Report. University of the West of England, Bristol, UK. Available at: http://eprints.uwe.ac.uk/29134

Clark, S. D. (2009). The determinants of car ownership in England and Wales from anonymous 2001 census data. *Transportation Research Part C: Emerging Technologies*, 17(5), 526–540.

Clarke, D. D., Ward, P., Bartle, C. and Truman, W. (2010). Older drivers' road traffic crashes in the UK. *Accident Analysis & Prevention*, 42(4), 1018–1024.

Clayton, W., Parkhurst, G., Paddeu, D. and Parkin, J. (submitted). Autonomous vehicles: willingness-to-pay and willingness-to-share.

Clewlow, R.R. (2016). Carsharing and sustainable travel behavior: Results from the San Francisco Bay Area. *Transport Policy*, 51, 158–164.

Codagnone, C., Veltri, G., Bogliacino, F., Lupiáñez-Villanueva, F., Gaskell, G., Ivchenko, A., Ortoleva, P. and Mureddu, F. (2016). Labels as nudges? An experimental study of car eco-labels. *EconomiaPolitica*, 33(3), 403–432.

Coffman, M., Bernstein, P. and Wee, S. (2017). Electric vehicles revisited: a review of factors that affect adoption. *Transport Reviews*, 37(1), 79–93.

Collins, C. M. and Chambers, S.M., 2005. Psychological and situational influences on commuter-transport-mode choice. *Environment and behavior, 37(5),* 640–661.

Cowan, R. and Hultén, S. (1996). Escaping lock-in: the case of the electric vehicle. *Technological Forecasting & Social Change*, 53(1), 61–79.

Cozens, P., Neale, R., Whitaker, J. and Hillier, D. (2003). Managing crime and the fear of crime at railway stations – a case study in South Wales (UK). *International Journal of Transport Management*, 1(3), 121–132.

Curl, A., Nelson, J. D. and Anable, J. (2015). Same question, different answer: A comparison of GIS-based journey time accessibility with self-reported measures from the National Travel Survey in England. *Computers, Environment and Urban Systems*, 49, 86–97.

Dalton, A. M., Jones, A. P., Panter, J. R. and Ogilvie, D. (2013). Neighbourhood, route and workplace-related environmental characteristics predict adults' mode of travel to work. *PloS one*, 8(6), e67575.

Dargay, J. (2008). Personal Transport Choice (pp. 59–94). In Ferrara, I. Serret, Y. *Household Behaviour and the Environment, Reviewing the Evidence* (pp. 153–180). Organisation for Economic Cooperation and Development: Paris, France.

Dargay, J. M. (2001). The effect of income on car ownership: evidence of asymmetry. *Transportation Research Part A: Policy and Practice*, 35(9), 807–821.

Dargay, J. M. and Clark, S. (2012). The determinants of long distance travel in Great Britain. *Transportation Research Part A: Policy and Practice*, 46(3), 576–587.

Dargay, J. and Hanly, M. (2007). Volatility of car ownership, commuting mode and time in the UK. *Transportation Research Part A: Policy and Practice*, 41(10), 934–948.

Degirmenci, K. and Breitner, M. H. (2017). Consumer purchase intentions for electric vehicles: Is green more important than price and range?. *Transportation Research Part D: Transport and Environment,* 51, 250–260.

Department for Transport (2015). *National Travel Survey*: England 2014. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/457752/nts2014-01.pdf

Department for Transport (2016). *National Travel Survey: England 2016*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/633077/national-travel-survey-2016.pdf

Department for Transport. (2017). *Cycling and walking investment strategy*. London, DfT.

Dimitropoulos, A., Rietveld, P. and Van Ommeren, J. N. (2013). Consumer valuation of changes in driving range: A meta-analysis. *Transportation Research Part A: Policy and Practice*, 55, 27–45.

Dumortier, J., Siddiki, S., Carley, S., Cisney, J., Krause, R. M., Lane, B. W., Rupp, J. A. and Graham, J. D. (2015). Effects of providing total cost of ownership information on consumers' intent to purchase a hybrid or plug-in electric vehicle. *Transportation Research Part A: Policy and Practice*, 72, 71–86.

Edwards, J. B., McKinnon, A. C. and Cullinane, S. L. (2010). Comparative analysis of the carbon footprints of conventional and online retailing: A 'last mile' perspective. *International Journal of Physical Distribution & Logistics Management*, 40(1/2), 103–123.

Ellaway, A. Macdonald, L. Kearns, A. (2016). Are housing tenure and car access still associated with health? A repeat cross-sectional study of UK adults over a 13-year period. *BMJ open*, 6(11), e012268.

Ellaway, A. Macintyre, S. Hiscock, R. Kearns, A. (2003). In the driving seat: psychosocial benefits from private motor vehicle transport compared to public transport. *Transportation Research Part F: Traffic Psychology and Behaviour,* 6(3), 217–231.

Elzen, B., Geels, F. and Hofman, P. (2004). Sociotechnical scenarios as a tool for transition policy: an example from the traffic and transport domain. In B. Elzen, F. Geels, K. Green (eds.), *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy,* Edward Elgar Publishers, Camberley, UK.

Eurobarometer, S. (2008). Attitudes of European citizens towards the environment. *European Commission*, 295.

Ewing, R. and Cervero, R. (2010). Travel and the built environment: a meta-analysis. *Journal of the American Planning Association*, 76(3), 265–294.

Fagnant, D. J. and Kockelman, K. (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy and Practice*, 77, 167–181.

Felstead, A. (2012). Rapid change or slow evolution? Changing places of work and their consequences in the UK. *Journal of Transport Geography*, 21, 31–38.

Firnkorn, J. (2012). Triangulation of two methods measuring the impacts of a free-floating carsharing system in Germany. *Transportation Research Part A: Policy and Practice*, 46(10), 1654–1672.

Fishman, E. (2016). Bikeshare: A review of recent literature. *Transport Reviews*, 36(1), 92–113.

Fishman, E., Washington, S. and Haworth, N. (2013). Bike share: a synthesis of the literature. *Transport reviews*, 33(2), 148–165.

Flamm, B. Agrawal, A. (2012). Constraints to green vehicle ownership: A focus group study. *Transportation Research Part D: Transport and Environment,* 17(2), 108–115.

Focas, C. and Christidis, P. (2017). Peak Car in Europe? *Transportation Research Procedia*, 25, 531–550.

Foley, L., Prins, R., Crawford, F., Sahlqvist, S., Ogilvie, D. and M74 study team. (2017). Effects of living near a new urban motorway on the travel behaviour of local residents in deprived areas: Evidence from a natural experimental study. *Health & place*, 43, 57–65.

Fouquet, R. (2014). Long run demand for energy services: Income and price elasticities over two hundred years. *Review of Environmental Economics and Policy*, 8(2), 186–207.

Fraedrich, E. and Lenz, B. (2014). Automated driving: Individual and societal aspects. *Transportation Research Record: Journal of the Transportation Research Board* (2416), 64–72.

Fujii, S., Gärling, T. and Kitamura, R. (2001). Changes in drivers' perceptions and use of public transport during a freeway closure: Effects of temporary structural change on cooperation in a real-life social dilemma. *Environment and Behavior*, 33(6), 796–808.

Gardner, B. & Abraham, C. (2007). What drives car use? A grounded theory analysis of commuters' reasons for driving. *Transportation Research Part F*, 10, 187–200.

Gatersleben, B. and Uzzell, D. (2007). Affective appraisals of the daily commute: Comparing perceptions of drivers, cyclists, walkers, and users of public transport. *Environment and behavior*, 39(3), 416–431.

Geels, F. W. and Schot, J. (2007). Typology of sociotechnical transition pathways. *Research policy*, 36(3), 399–417.

Geels, F. W. (2005). *Technological transitions and system innovations: a co-evolutionary and socio-technical analysis*. Edward Elgar Publishing.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental innovation and societal transitions*, 1(1), 24–40.

Ghazizadeh, M., Lee, J. D. and Boyle, L. N. (2012). Extending the technology acceptance model to assess automation. *Cognitive Technology and Work*, 14, 39–49.

Giesel, F. and Nobis, C. (2016). The Impact of Carsharing on Car Ownership in German Cities. *Transportation Research Procedia*, 19, 215–224.

Givoni, M. (2012). Re-assessing the results of the London congestion charging scheme. *Urban Studies*, 49(5), 1089–1105.

Glazer, A. and Niskanen, E. (1992). Parking fees and congestion. *Regional Science and Urban Economics*, 22(1), 123–132.

Gold, C., Körbera, M., Hohenbergerb, C., Lechnera, D and Bengler, K. (2015). Trust in automation – before and after the experience of take-over scenarios in a highly automated vehicle. *Procedia Manufacturing*, 3, 3025–3032.

Goodman, A. (2013). Walking, cycling and driving to work in the English and Welsh 2011 census: trends, socio-economic patterning and relevance to travel behaviour in general. *PloS one*, 8(8), p.e71790.

Goodwin, P., Dargay, J. and Hanly, M. (2004). Elasticities of road traffic and fuel consumption with respect to price and income: a review. *Transport Reviews,* 24(3), 275–292.

Goodwin, P., Hallett, S., Kenny, F. and Stokes, G. (1991). *Transport: the new realism*. Transport Studies Unit, University of Oxford, 67, 73–85.

Goulden, M., Ryley, T. and Dingwall, R. (2014). Beyond 'predict and provide': UK transport, the growth paradigm and climate change. *Transport Policy*, 32, 139–147.

Graham, D. J., Crotte, A. and Anderson, R. J. (2009). A dynamic panel analysis of urban metro demand. *Transportation Research Part E: Logistics and Transportation Review*, 45(5), 787–794.

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R. and Stannard, J. (2012). Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. *Transportation Research Part A: Policy and Practice*, 46(1), 140–153.

Graham-Rowe, E., Skippon, S., Gardner, B. and Abraham, C. (2011). Can we reduce car use and, if so, how? A review of available evidence. *Transportation Research Part A: Policy and Practice*, 45(5), 401–418.

Greene, D. (2010). *How consumers value fuel economy: A literature* review (No. EPA-420-R-10-008). Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P1006V0O.PDF?Dockey=P1006V0O.PDF

Groffen, D. A., Koster, A., Bosma, H., van den Akker, M., Aspelund, T., Siggeirsdóttir, K., Siggeirsdóttir K, Kempen, G.I., van Eijk, J.T., Eiriksdottir, G., Jónsson, P.V., Launer L.J., Gudnason, V. and Harris T.B. (2013). Socioeconomic factors from midlife predict mobility limitation and depressed mood three decades later; Findings from the AGES-Reykjavik Study. *BMC Public Health*, 13(1), 101.

Haboucha, C.J., Ishaq, R. and Shiftan, Y. (2017). User preferences regarding autonomous vehicles. *Transportation Research Part C: Emerging Technologies*, 78, 37–49.

Hackbarth, A. and Madlener, R. (2013). Consumer preferences for alternative fuel vehicles: A discrete choice analysis. *Transportation Research Part D: Transport and Environment*, 25, 5–17.

Hafner, R. Walker, I. Verplanken, B. (2017). Image, not environmentalism: A qualitative exploration of factors influencing vehicle purchasing decisions. *Transportation Research Part A: Policy and Practice*, 97, 89–105.

Hagman, O. (2003). Mobilizing meanings of mobility: car users' constructions of the goods and bads of car use. *Transportation Research Part D: Transport and Environment*, 8(1), 1–9.

Hamari, J., Sjöklint, M. and Ukkonen, A. (2016). The sharing economy: Why people participate in collaborative consumption. *Journal of the Association for Information Science and Technology*, 67(9), 2047–2059.

Hancock, P. A., Billings, D. R., Schaefer, K. E., Chen, J. Y. C., De Visser, E. J. and Parasuraman, R. (2011). A meta-analysis of factors affecting trust in human-robot interaction. *Human Factors*, 53(5), 517–527.

Hardman, S., Shiu, E. and Steinberger-Wilckens, R. (2016). Comparing high-end and low-end early adopters of battery electric vehicles. *Transportation Research Part A: Policy and Practice*, 88, 40–57.

Hass-Klau, C. (1993). Impact of pedestrianization and traffic calming on retailing: A review of the evidence from Germany and the UK. *Transport Policy*, 1(1), 21–31.

Haustein, S. and Hunecke, M., 2007. Reduced use of environmentally friendly modes of transportation caused by perceived mobility necessities: An extension of the theory of planned behavior. *Journal of Applied Social Psychology*, 37(8), 1856–1883.

Hawkins, T. R., Singh, B., Majeau-Bettez, G. and Strømman, A. H. (2013). Comparative environmental life cycle assessment of conventional and electric vehicles. *Journal of Industrial Ecology*, 17(1), 53–64.

Hazée, S., Delcourt, C. and Van Vaerenbergh, Y. (2017). Burdens of Access: Understanding Customer Barriers and Barrier-Attenuating Practices in Access-Based Services. *Journal of Service Research*, 20(4), 441–456.

Heinen, E. and Mattioli, G. (2017). Does a high level of multimodality mean less car use? An exploration of multimodality trends in England. *Transportation*, 1–34.

Heinen, E., Panter, J., Mackett, R. and Ogilvie, D. (2015). Changes in mode of travel to work: a natural experimental study of new transport infrastructure. *The International Journal of Behavioral Nutrition and Physical Activity*, 12, 81.

Hiscock, R. Macintyre, S. Kearns, A. and Ellaway, A. (2002). Means of transport and ontological security: Do cars provide psycho-social benefits to their users? *Transportation Research Part D: Transport and Environment*, 7(2), 119–135.

Hoehner, C. M., Ramirez, L. K. B., Elliott, M. B., Handy, S. L. and Brownson, R. C. (2005). Perceived and objective environmental measures and physical activity among urban adults. *American journal of preventive medicine*, 28(2), 105–116.

Hoffmann, C., Abraham, C., White, M. P., Ball, S. and Skippon, S. M. (2017). What cognitive mechanisms predict travel mode choice? A systematic review with meta-analysis. *Transport Reviews*, 1–22.

Howard, D. and Dai, D. (2014). Public perceptions of self-driving cars: The case of Berkeley, California. In *Transportation Research Board 93rd Annual Meeting* (Vol. 14, No. 4502).

Hulse, L. M., Xie, H. and Galea, E. R. (2018). Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. *Safety Science*, 102, 1–13.

Hunecke, M., Haustein, S., Grischkat, S. and Böhler, S., 2007. Psychological, sociodemographic, and infrastructural factors as determinants of ecological impact caused by mobility behavior. *Journal of Environmental Psychology*, 27(4), 277–292.

Hynes, M. (2014). Telework Isn't Working: A Policy Review. *The Economic and Social Review*, 45(4), 579–602.

Jahanshahi, K. and Jin, Y. (2016). The built environment typologies in the UK and their influences on travel behaviour: new evidence through latent categorisation in structural equation modelling. *Transportation Planning and Technology*, 39(1), 59–77.

Jahanshahi, K., Jin, Y. and Williams, I. (2015). Direct and indirect influences on employed adults' travel in the UK: New insights from the National Travel Survey data 2002–2010. *Transportation Research Part A: Policy and Practice,* 80, 288–306.

Jansson, J., Pettersson, T., Mannberg, A., Brännlund, R. and Lindgren, U. (2017). Adoption of alternative fuel vehicles: Influence from neighbors, family and coworkers. *Transportation Research Part D: Transport and Environment*, 54, 61–73.

Jensen, A. F., Cherchi, E. and Mabit, S. L. (2013). On the stability of preferences and attitudes before and after experiencing an electric vehicle. *Transportation Research Part D: Transport and Environment*, 25, 24–*32.*

Jensen, M. (1999). Passion and heart in transport—a sociological analysis on transport behaviour. *Transport Policy*, 6(1), 19–33.

Joo, J. H., *Motives for Participating in Sharing Economy: Intentions to Use Car Sharing Services*.

Kan, M. Y., Sullivan, O. and Gershuny, J. (2011). Gender convergence in domestic work: Discerning the effects of interactional and institutional barriers from large-scale data. *Sociology*, 45(2), 234–251.

Kanger, L. and Schot, J. (2016). User-made immobilities: a transitions perspective. *Mobilities*, 11(4), 598–613.

Kaplan, R. and Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. Cambridge University Press.

Kemp, R., Schot, J. and Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management, *Technological Analysis & Strategic Management*, 10(2), 175–195.

Kihm, A. and Vance, C. (2016). The determinants of equity transmission between the new and used car markets: a hedonic analysis. *Journal of the Operational Research Society*, 67(10), 1250–1258.

Kim, J., Rasouli, S. and Timmermans, H. (2017). Satisfaction and uncertainty in car-sharing decisions: An integration of hybrid choice and random regret-based models. *Transportation Research Part A: Policy and Practice*, 95, 13–33.

Klöckner, C.A. and Friedrichsmeier, T. (2011). A multi-level approach to travel mode choice–How person characteristics and situation specific aspects determine car use in a student sample. *Transportation Research Part F: Traffic Psychology and Behaviour*, 14(4), 261–277.

Körber, M., Baseler, E. and Bengler, K. (2018). Introduction matters: Manipulating trust in automation and reliance in automated driving. *Applied Ergonomics,* 66, 18–31.

Krueger, R., Rashidi, T.H. and Rose, J.M. (2016). Preferences for shared autonomous vehicles. *Transportation research part C: emerging technologies*, 69, 343–355.

Kuhnimhof, T., Armoogum, J., Buehler, R., Dargay, J., Denstadli, J. M. and Yamamoto, T. (2012). Men shape a downward trend in car use among young adults – evidence from six industrialized countries. *Transport Reviews*, 32(6), 761–779.

Kurz, T. Gardner, B. Verplanken, B. and Abraham, C. (2015). Habitual behaviors or patterns of practice? Explaining and changing repetitive climate-relevant actions. *WIREs Climate Change*, 6, 113–128.

Kyriakidis, M., Happee, R. and de Winter, J.C. (2015). Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. *Transportation research part F: traffic psychology and behaviour*, 32, 127–140.

Lane, B. and Potter, S. (2007). The adoption of cleaner vehicles in the UK: exploring the consumer attitude–action gap. *Journal of cleaner production*, 15(11), 1085–1092.

Lanzini, P. and Khan, S. A. (2017). Shedding light on the psychological and behavioral determinants of travel mode choice: A meta-analysis. *Transportation Research Part F: Traffic Psychology and Behaviour*, 48, 13–27.

Law, R. (1999). Beyond ‘women and transport’: towards new geographies of gender and daily mobility. *Progress in Human Geography*, 23(4), 567–588.

Le Vine, S.E. and Polak, J.W. (2017). *The impact of free-floating carsharing on car ownership: Early-stage findings from London*

Le Vine, S.E., Zolfaghari, A. and Polak, J.W. (2015). Autonomous cars: The tension between occupant experience and intersection capacity. *Transportation Research Part C: Emerging Technologies*, 52, 1–14.

Lee, J. D. and See, K. A. (2004). Trust in Automation: Designing for Appropriate Reliance. *Human Factors*, 46(1), 50–80.

Lee, J. and Moray, N. (1992). Trust, control strategies and allocation of function in human-machine-systems. *Ergonomics*, 35(10), 1243–1270.

Leiser, D., Stern, E. and Meyer, J. (1991). Mean velocity and total time estimation effects of order and proportions. *Journal of Environmental Psychology*, 11(4), 347–358.

Lewin, K. (1939). Field theory and experiment in social psychology: concepts and methods. *American Journal of Sociology*, 44(6), 868–896.

Li, Y. W. (2003). Evaluating the urban commute experience: A time perception approach. *Journal of Public Transportation*, 6(4), 3.

Li, W., Long, R., Chen, H. and Geng, J. (2017). A review of factors influencing consumer intentions to adopt battery electric vehicles. *Renewable and Sustainable Energy Reviews*, 78, 318–328.

Litman, T. (2004). Transit price elasticities and cross-elasticities. *Journal of Public Transportation*, 7(2), 3.

Litman, T. (2008). Valuing transit service quality improvements. *Journal of Public transportation*, 11(2), 3.

Litman, T. (2017). *Generated Traffic and Induced Travel: implications for transport policy*. Victoria, Victoria Transport Policy Institute. Available at: http://www.vtpi.org/gentraf.pdf

Loorbach, D. (2007). *Transition Management*, International Books, Grithoek.

Lorenc, T., Petticrew, M., Whitehead, M., Neary, D., Clayton, S., Wright, K., ... and Renton, A. (2013). Fear of crime and the environment: systematic review of UK qualitative evidence. *BMC Public Health*, 13(1), 496.

Lucas, K. (2009). Actual and perceived car dependence: likely implications of enforced reductions in car use for livelihoods, lifestyles, and well-being. *Transportation Research Record: Journal of the Transportation Research Board* (2118), 8–15.

Lyons, G. (2015). Transport's digital age transition. *Journal of Transport and Land Use*, 8(2), 1–19.

Mann, E. and Abraham, C. (2006). The role of affect in UK commuters' travel mode choices: An interpretative phenomenological analysis. *British Journal of Psychology*, 97, 155–176.

Mann, E. and Abraham, C. (2012). Identifying beliefs and cognitions underpinning commuters' travel mode choices. *Journal of Applied Social Psychology,* 42(11), 2730–2757.

Marletto, G. (2010). Structure, agency and change in the car regime: a review of the literature. *European Transport*, 47, 71–88.

Marsden, G. (2006). The evidence base for parking policies: a review. *Transport Policy, 13(6),* 447–457.

Martin, E.W. and Shaheen, S.A. (2011). Greenhouse gas emission impacts of carsharing in North America. *IEEE Transactions on Intelligent Transportation Systems*, 12(4), 1074–1086.

Matthews, W. J. and Meck, W. H. (2014). Time perception: the bad news and the good. Wiley Interdisciplinary Reviews: *Cognitive Science*, 5(4), 429–446.

Mattioli, G., Lucas, K. and Marsden, G. (2017). Transport poverty and fuel poverty in the UK: From analogy to comparison. *Transport Policy*, 59, 93–105.

McIlroy, R. C., Stanton, N. A. and Godwin, L. (2017). Good vibrations: using a haptic accelerator pedal to encourage eco-driving. *Transportation Research Part F: Traffic Psychology and Behaviour*, 46, 34–46.

Mejia-Dorantes, L. and Lucas, K. (2014). Public transport investment and local regeneration: A comparison of London's Jubilee Line Extension and the Madrid Metrosur. *Transport Policy*, 35, 241–252.

Melia, S. (2015) Randomised controlled trials, evidence hierarchies and smarter choices. *World Transport Policy & Practice*, 21(2), 64–71.

Melia, S. and Shergold, I. (2016) Pedestrianisation and politics: Evidence gaps and a case study of Brighton's Old Town. In *Universities Transport Study Group*, Bristol, January 2016. Available at: http://eprints.uwe.ac.uk/27971

Melia, S., Barton, H. and Parkhurst, G. (2013). Potential for carfree development in the UK. *Urban Design and Planning*, 166 (2), 136–145.

Melo, P. C. and e Silva, J. D. A. (2017). Home telework and household commuting patterns in Great Britain. *Transportation Research Part A: Policy and Practice*, 103, 1–24.

Merat, N., Jamson, A. H., Lai, F.C., Daly, M. and Carsten, O. M. (2014). Transition to manual: Driver behaviour when resuming control from a highly automated vehicle. *Transportation research part F: traffic psychology and behaviour*, 27, 274–282.

Metz, D. (2008). The myth of travel time saving. *Transport Reviews*, 28(3), 321–336.

Metz, D. (2012). Demographic determinants of daily travel demand. *Transport Policy*, 21, 20–25.

Metz, D. (in press). Valuing transport investments based on travel time saving: Inconsistency with United Kingdom policy objectives. *Case Studies on Transport Policy.*

Midgley, D.F. and Dowling, G.R. (1978). Innovativeness: The concept and its measurement. *Journal of consumer research*, 4(4), 229–242.

Moeller, S. and Wittkowski, K. (2010). The burdens of ownership: reasons for preferring renting. *Managing Service Quality: An International Journal*, 20(2), 176–191.

Möhlmann, M. (2015). Collaborative consumption: determinants of satisfaction and the likelihood of using a sharing economy option again. *Journal of Consumer Behaviour*, 14(3), 193–207.

Morgan, P. L., Williams, C., Flower, J., Alford, C. and Parkin, J. (2018, accepted). Trust in an autonomously driven simulator and vehicle performing manoeuvres at a T-junction with and without other vehicles. *To appear in: Advances in Human Aspects of Transportation: Proceedings of the 9th Applied Human Factors and Ergonomics (2018) International Conference*.

Morgan, P., Alford, C., Williams, C., Parkhurst, G. and Pipe, A. (2017). Manual takeover and handover of a simulated fully autonomous vehicle within urban and extra urban settings. In Stanton, N. A., ed*. Advances in Human Aspects of Transportation*: Proceedings of the AHFE 2017 International Conference on Human Factors in Transportation (597) Springer, 760–771.

Morris, E. A. and Guerra, E. (2015). Are we there yet? Trip duration and mood during travel. *Transportation Research Part F: Traffic Psychology and Behaviour*, 33, 38–47.

Morton, C., Anable, J. and Nelson, J. D. (2016). Exploring consumer preferences towards electric vehicles: The influence of consumer innovativeness. *Research in Transportation Business & Management*, 18, 18–28.

Möser, G. and Bamberg, S. (2008). The effectiveness of soft transport policy measures: A critical assessment and meta-analysis of empirical evidence. *Journal of Environmental Psychology*, 28(1), 10–26.

Murtagh, N., Gatersleben, B. and Uzzell, D. (2014). 16 Identity threat and resistance to change: evidence and implications from transport-related behavior. *Identity Process Theory: Identity, Social Action and Social Change*, 32(4), 335.

Musselwhite, C. B. and Shergold, I. (2013). Examining the process of driving cessation in later life. *European Journal of Ageing*, 10(2), 89–100.

Næss, P., Strand, A., Wolday, F. and Stefansdottir, H. (2017). Residential location, commuting and non-work travel in two urban areas of different size and with different center structures. *Progress in Planning*, in press.

Nayum, A. and Klöckner, C. A. (2014). A comprehensive socio-psychological approach to car type choice. *Journal of Environmental Psychology*, 40, 401–411.

Nielsen, J.R., Hovmøller, H., Blyth, P.L. and Sovacool, B.K., 2015. Of ‘white crows’ and ‘cash savers:’ A qualitative study of travel behavior and perceptions of ridesharing in Denmark. *Transportation Research Part A: Policy and Practice*, 78, 113–123.

Nijland, H. and van Meerkerk, J. (2017). Mobility and environmental impacts of car sharing in the Netherlands. *Environmental Innovation and Societal Transitions*, 23, 84–91.

Noppers, E. Keizer, K. Bolderdijk, J. and Steg, L. (2014). The adoption of sustainable innovations: driven by symbolic and environmental motives. *Global Environmental Change*, 25, 52–62.

Nordh, H., Vistad, O. I., Skår, M., Wold, L. C. and Bærum, K. M. (2017). Walking as urban outdoor recreation: Public health for everyone. *Journal of Outdoor Recreation and Tourism*.

Nurhadi, L., Borén, S., Ny, H. and Larsson, T. (2017). Competitiveness and sustainability effects of cars and their business models in Swedish small town regions. *Journal of Cleaner Production*, 140, 333–348.

Nykvist, B. and Whitmarsh, L. (2008). A multi-level analysis of sustainable mobility transitions: Niche development in the UK and Sweden. *Technological forecasting and social change*, 75(9), 1373–1387.

Office for National Statistics. (2013). *Statistics on Obesity, Physical Activity and Diet*. Available at: https://data.gov.uk/dataset/a7fb45df-7566-488b-80d8-a5dd5e52ff32/statistics-on-obesity-physical-activity-and-diet-england

Ogilvie, D., Bull, F., Cooper, A., Rutter, H., Adams, E., Brand, C., Ghali, K., Jones, T., Mutrie, N., Powell, J. and Preston, J. (2012). Evaluating the travel, physical activity and carbon impacts of a 'natural experiment' in the provision of new walking and cycling infrastructure: methods for the core module of the iConnect study. *BMJ Open*, 2(1), e000694.

Ogilvie, D., Egan, M., Hamilton, V. and Petticrew, M., 2004. Promoting walking and cycling as an alternative to using cars: systematic review. *BMJ*, 329(7469), 763.

Ogilvie, D., Mitchell, R., Mutrie, N., Petticrew, M. and Platt, S. (2006). Evaluating health effects of transport interventions: methodologic case study. *American Journal of Preventive Medicine*, 31(2), 118–126.

Ogilvie, D., Mitchell, R., Mutrie, N., Petticrew, M. and Platt, S. (2008). Personal and environmental correlates of active travel and physical activity in a deprived urban population. *International Journal of Behavioral Nutrition and Physical Activity*, 5(1), 43.

ONS (2017). *Overview of the UK Population: July 2017*. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/july2017/pdf

Ory, D. T. and Mokhtarian, P. L. (2005). When is getting there half the fun? Modeling the liking for travel. *Transportation Research Part A: Policy and Practice*, 39(2), 97–123.

Panter, J., Griffin, S., Dalton, A. M. and Ogilvie, D. (2013). Patterns and predictors of changes in active commuting over 12 months. *Preventive Medicine*, 57(6), 776–784.

Panter, J., Griffin, S., Jones, A., Mackett, R. and Ogilvie, D. (2011). Correlates of time spent walking and cycling to and from work: baseline results from the commuting and health in Cambridge study. *International Journal of Behavioral Nutrition and Physical Activity*, 8(1), 124.

Panter, J., Heinen, E., Mackett, R. and Ogilvie, D. (2016). Impact of new transport infrastructure on walking, cycling, and physical activity. *American Journal of Preventive Medicine*, 50(2), e45-e53.

Parasuraman, R., Sheridan, T. B. and Wickens, C. D. (2008). Situation awareness, mental workload, and trust in automation: Viable, empirically supported cognitive engineering constructs. *Journal of Cognitive Engineering and Decision Making*, 2, 140–160.

Park, J.K. and John, D.R. (2011). More than meets the eye: The influence of implicit and explicit self-esteem on materialism. *Journal of consumer psychology*, 21(1), 73–87.

Paulley, N., Balcombe, R., Mackett, R., Titheridge, H., Preston, J., Wardman, M. and White, P. (2006). The demand for public transport: The effects of fares, quality of service, income and car ownership. *Transport Policy*, 13(4), 295–306.

Paundra, J., Rook, L., van Dalen, J. and Ketter, W. (2017). Preferences for car sharing services: Effects of instrumental attributes and psychological ownership. *Journal of Environmental Psychology*, 53, 121–130.

Pavlou, P. A. (2003). Consumer acceptance of electronic commerce: Integrating trust and risk with the technology acceptance model. *International Journal of Electronic Commerce*, 7, 101–134.

Peer, S., Knockaert, J., Koster, P. and Verhoef, E. T. (2014). Over-reporting vs. overreacting: Commuters' perceptions of travel times. *Transportation Research Part A: Policy and Practice*, 69, 476–494.

Peters, A., Gutscher, H. and Scholz, R. W. (2011). Psychological determinants of fuel consumption of purchased new cars. *Transportation Research Part F: Traffic Psychology and Behaviour*, 14(3), 229–239.

Pettifor, H., Wilson, C., Axsen, J., Abrahamse, W. and Anable, J. (2017). Social influence in the global diffusion of alternative fuel vehicles – A meta-analysis. *Journal of Transport Geography*, 62, 247–261.

Pop, V. L., Shrewsbury, A. and Durso, F. T. (2015). Individual differences in the calibration of trust in automation. *Human factors*, 57(4), 545–556.

Poushter, J. (2016). Smartphone ownership and internet usage continues to climb in emerging economies. *Pew Research Center*, 22.

Prieto, M., Baltas, G. and Stan, V. (2017). Car sharing adoption intention in urban areas: What are the key sociodemographic drivers?. *Transportation Research Part A: Policy and Practice*, 101, 218–227.

Prillwitz, J. and Barr, S. (2011). Moving towards sustainability? Mobility styles, attitudes and individual travel behaviour. *Journal of Transport Geography,* 19(6), 1590–1600.

Reis, H. T., Sheldon, K. M., Gable, S. L., Roscoe, J. and Ryan, R. M. (2000). Daily well-being: The role of autonomy, competence, and relatedness. *Personality and Social Psychology Bulletin*, 26(4), 419–435.

Rezvani, Z., Jansson, J. and Bodin, J. (2015). Advances in consumer electric vehicle adoption research: A review and research agenda. *Transportation research part D: transport and environment*, 34, 122–136.

Rode, P., Floater, G., Thomopoulos, N., Docherty, J., Schwinger, P., Mahendra, A. and Fang, W. (2017). Accessibility in cities: transport and urban form. In *Disrupting Mobility* (pp. 239–273). Springer International Publishing.

Rogers, E. (1983). *The Diffusion of Innovations*. New York: Free Press.

Rogers, E. M. and Shoemaker, F. (1983). *Diffusion of innovation: A cross-cultural approach*. New York.

Rosenbloom, S. (2010). How adult children in the UK and the US view the driving cessation of their parents: Is a policy window opening? *Journal of Transport Geography*, 18(5), 634–641.

Ryan, R. M. and Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1), 68.

Ryan, R., Huta, V. and Deci, E. L. J. (2008). Living well: a self-determination theory perspective on eudaimonia. *Journal of Happiness Studies*, 9, 139.

Sallee, J. M., West, S. E. and Fan, W. (2016). Do consumers recognize the value of fuel economy? Evidence from used car prices and gasoline price fluctuations. *Journal of Public Economics*, 135, 61–73.

Santis, G. (2008). *London Congestion Charging*. Brookings-Wharton Papers on Urban Affairs, 177–234.

Santos, G. Behrendt, H. Maconi, L. Shirvani, T. and Teytelboym, A. (2010). Part I: Externalities and economic policies in road transport. *Research in Transportation Economics*, 28(1), 2–45.

Santos, G., Behrendt, H. and Teytelboym, A. (2010). Part II: Policy instruments for sustainable road transport. *Research in Transportation Economics*, 28(1), 46–91.

Schaefers, T., Lawson, S.J. and Kukar-Kinney, M. (2016). How the burdens of ownership promote consumer usage of access-based services. *Marketing Letters*, 27(3), 569–577.

Schmalfuß, F., Mühl, K. and Krems, J.F. (2017). Direct experience with battery electric vehicles (BEVs) matters when evaluating vehicle attributes, attitude and purchase intention. *Transportation research part F: traffic psychology and behaviour*, 46, 47–69.

Schoenduwe, R., Mueller, M. G., Peters, A. and Lanzendorf, M. (2015). Analysing mobility biographies with the life course calendar: a retrospective survey methodology for longitudinal data collection. *Journal of Transport Geography,* 42, 98–109.

Schoettle, B. and Sivak, M. (2014). *A survey of public opinion about autonomous and self-driving vehicles in the US, the UK, and Australia*.

Schouten, T. M. Bolderdijk, J. W. and Steg, L. (2014). Framing car fuel efficiency: linearity heuristic for fuel consumption and fuel-efficiency ratings. *Energy Efficiency*, 7(5), 891–901.

Schuitema, G., Anable, J., Skippon, S. and Kinnear, N. (2013). The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. *Transportation Research Part A: Policy and Practice*, 48, 39–49.

Schwanen, T., Dijst, M. and Dieleman, F. M. (2004). Policies for urban form and their impact on travel: the Netherlands experience. *Urban Studies*, 41(3), 579–603.

Settler (2017). Rapid evidence review: *The UK Private Road Transport System: How and why is it changing?* Imperial College, London on behalf of UK Government Office for Science.

Shaheen, S., Cohen, A. and Martin, E. (2010). Carsharing parking policy: Review of North American practices and San Francisco, California, Bay area case study. *Transportation Research Record: Journal of the Transportation Research Board* (2187), 146–156.

Shaw, J., Walton, W. and Farrington, J. (2003). Assessing the potential for a ‘railway renaissance’ in Great Britain. *Geoforum*, 34(2), 141–156.

Shergold, I. and Parkhurst, G. (2012) Transport-related social exclusion amongst older people in rural Southwest England and Wales. *Journal of Rural Studies*, 28(4), 412–421.

Shergold, I., Lyons, G. and Hubers, C. (2015). Future mobility in an ageing society– Where are we heading? *Journal of Transport & Health*, 2(1), 86–94.

Sivak, M. and Schoettle, B. (2012). Update: Percentage of young persons with a driver's license continues to drop. *Traffic Injury Prevention*, 13(4), 341.

Sloman, L., Cairns, S., Newson, C., Anable, J., Pridmore, A. and Goodwin, P. (2010). *The Effects of Smarter Choice Programmes in the Sustainable Travel Towns: Summary Report.* Available at: http://www.toolsofchange.com/userfiles/STT%20final%20evaluation%20summary.pdf

Smith, T. W., Kim, J. and Son, J. (2017). Public Attitudes toward Climate Change and Other Environmental Issues across Countries. *International Journal of Sociology*, 47(1), 62–80.

Spence, N. and Linneker, B. (1994). Evolution of the motorway network and changing levels of accessibility in Great Britain. *Journal of Transport Geography*, 2(4), 247–264.

Stapleton, L., Sorrell, S. and Schwanen, T. (2017). Peak car and increasing rebound: A closer look at car travel trends in Great Britain. *Transportation Research Part D: Transport and Environment*, 53, 217–233.

Steg, L. (2005). Car use: lust and must. Instrumental, symbolic and affective motives for car use. *Transportation Research Part A*, 39, 147–162.

Steg, L. Vlek, C. and Slotegraaf, G. (2001). Instrumental–Reasoned and Symbolic–Affective Motives for Using a Motorcar. *Transportation Research Part F: Traffic Psychology and Behaviour*, 4, 151–169.

Stillwater, T., Kurani, K. S. and Mokhtarian, P. L. (2017). The combined effects of driver attitudes and in-vehicle feedback on fuel economy. *Transportation Research Part D: Transport and Environment*, 52, 277–288.

Stuber, J., Galea, S. and Link, B.G. (2008). Smoking and the emergence of a stigmatized social status. *Social science & medicine*, 67(3), 420–430.

SUMMA (2005). *Final Publishable Report*. RAND Europe, Leiden.

Susilo, Y. O. and Cats, O. (2014). Exploring key determinants of travel satisfaction for multi-modal trips by different traveller groups. *Transportation Research Part A: Policy and Practice*, 67, 366–380.

Tenenboim, E. and Shiftan, Y. (2016). Accuracy and bias of subjective travel time estimates. *Transportation*, 1–25.

Thaler, R. H. (1999). Mental accounting matters. *Journal of Behavioral Decision Making*, 12(3), 183.

Thaler, R. Sunstein, C. (2008). *Nudge: Improving Decisions About Health, Wealth, and Happiness.* New Haven, CT: Yale University Press.

Thomas, G. Walker, I. Musselwhite, C. (2014). Grounded Theory analysis of commuters discussing a workplace carbon-reduction target: Autonomy, satisfaction, and willingness to change behaviour in drivers, pedestrians, bicyclists, motorcyclists, and bus users. *Transportation Research Part F: Traffic Psychology and Behaviour*, 26, 72–81.

Thornton, A. Evans, L. Bunt, K. Simon, A. King, S. and Webster, T. (2011*). Climate change and transport choices. Segmentation Model – A framework for* *reducing CO2 emissions from personal travel*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/49971/climate-change-transport-choices-full.pdf.

Tilley, S. and Houston, D. (2016). The gender turnaround: Young women now travelling more than young men. *Journal of Transport Geography*, 54, 349–358.

Transport Statistics Great Britain (2017). *Transport Statistics for Great Britain, 2016.* Department for Transport. Retrieved from: https://www.gov.uk/government/statistics/transport-statistics-great-britain-2016

Tsouros, I., Polydoropoulou, A. and Tsirimpa, A. (2017), June. Multimodal alternatives: How do users perceive the different combination of modes?. In *Models and Technologies for Intelligent Transportation Systems (MT-ITS) (2017) 5th IEEE International Conference* (497–502). IEEE.

Turrentine, T. and Kurani, K. (2007). Car buyers and fuel economy? *Energy Policy,* 35(2), 1213–1223.

Ünal, A. B., Steg, L. and Gorsira, M. (2017). Values Versus Environmental Knowledge as Triggers of a Process of Activation of Personal Norms for Eco-Driving. *Environment and Behavior*, in press.

Urry, J. (2004). The 'system' of automobility. *Theory, Culture & Society,* 21(4–5), 25–39.

Vaezipour, A., Rakotonirainy, A. and Haworth, N. (2015). Reviewing in-vehicle systems to improve fuel efficiency and road safety. *Procedia Manufacturing,* 3, 3192–3199.

Van Acker, V. and Witlox, F. (2010). Car ownership as a mediating variable in car travel behaviour research using a structural equation modelling approach to identify its dual relationship. *Journal of Transport Geography,* 18(1), 65–74.

van Exel, N. J. A. and Rietveld, P. (2010). Perceptions of public transport travel time and their effect on choice-sets among car drivers. *Journal of Transport & Land Use*, 2(3), 75–86.

Van Krevelen, D. W. F. and Poelman, R. (2010). A survey of augmented reality technologies, applications and limitations. *International Journal of Virtual Reality*, 9(2), 1.

Vassileva, I. and Campillo, J. (2017). Adoption barriers for electric vehicles: Experiences from early adopters in Sweden. *Energy*, 120, 632–641.

Verplanken, B. and Aarts, H. (1999). Habit, Attitude, and Planned Behaviour: Is Habit an Empty Construct or an Interesting Case of Goal-directed Automaticity? *European Review of Social Psychology*, 10(1), 101–134.

Verplanken, B. Aarts, H. and Van Knippenberg, A. (1997). Habit, information acquisition, and the process of making travel mode choices. *European Journal of Social Psychology*, 27, 539–560.

Verplanken, B. Aarts, H. Van Knippenberg, A. and Van Knippenberg, C. (1994) Attitude Versus General Habit: Antecedents of Travel Mode Choice. *Journal of Applied Social Psychology*, 24(4), 285–300.

Verplanken, B. and Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy & Marketing*, 25(1), 90–103.

Verplanken, B., Walker, I., Davis, A. and Jurasek, M. (2008). Context change and travel mode choice: Combining the habit discontinuity and self-activation hypotheses. *Journal of Environmental Psychology*, 28(2), 121–127.

Vilhelmson, B. and Thulin, E. (2016). Who and where are the flexible workers? Exploring the current diffusion of telework in Sweden. *New Technology, Work and Employment*, 31(1), 77–96.

Vreeswijk, J., Thomas, T., van Berkum, E. and van Arem, B. (2014). Perception bias in route choice. *Transportation*, 41(6), 1305–1321.

Walker, I., Thomas, G.O. and Verplanken, B. (2015). Old habits die hard: Travel habit formation and decay during an office relocation. *Environment and Behavior, 47(10),* 1089–1106.

Wall, G., Bukola, O., Olaniyan, B., Woods, L. and Musselwhite, C. (2017). Encouraging sustainable modal shift – An evaluation of the Portsmouth Big Green Commuter Challenge. *Case Studies on Transport Policy*, 5(1), 105–111.

Wardman, M. (2001). *Public Transport Values of Time*. Institute of Transport Studies, University of Leeds, Working Paper 564. Available at: http://eprints.whiterose.ac.uk/2062/1/ITS37_WP564_uploadable.pdf

Wasfi, R., Steinmetz-Wood, M. and Levinson, D. (2017). Measuring the transportation needs of people with developmental disabilities: A means to social inclusion. *Disability and health journal*, 10(2), 356–360.

Wells, P. and Xenias, D. (2015). From ‘freedom of the open road’ to ‘cocooning’: Understanding resistance to change in personal private automobility. *Environmental Innovation and Societal Transitions*, 16, 106–119.

Whelan, G. (2007). Modelling car ownership in Great Britain. *Transportation Research Part A: Policy and Practice*, 41(3), 205–219.

White, L. V. and Sintov, N. D. (2017). You are what you drive: Environmentalist and social innovator symbolism drives electric vehicle adoption intentions. *Transportation Research Part A: Policy and Practice*, 99, 94–113.

Whitmarsh, L. and Köhler, J. (2010). Climate change and cars in the EU: the roles of auto firms, consumers, and policy in responding to global environmental change. *Cambridge Journal of Regions, Economy and Society*, 3(3), 427–441.

Wilhelms, M.P., Henkel, S. and Falk, T. (2017). To earn is not enough: A means-end analysis to uncover peer-providers' participation motives in peer-to-peer carsharing. *Technological Forecasting and Social Change*.

Wu, G., Inderbitzin, A. and Bening, C. (2015). Total cost of ownership of electric vehicles compared to conventional vehicles: A probabilistic analysis and projection across market segments. *Energy Policy, 80, 196*–214.

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