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Human Factors in Exclusive and Shared Use in the UK Transport System

Future of Mobility: Evidence Review

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Human Factors in Exclusive and Shared Use in the UK Transport System

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Executive summary

Transport sharing describes a growing set of practices, systems and services that sit between traditional notions of private and public transport provision, and may have benefits in terms of both improving mobility in society and helping to address environmental challenges. This report highlights those factors relevant to a human- or user-centric adoption of shared travel, with a view to identifying the factors that currently encourage or discourage shared travel, and the emerging social and technological developments that will influence both the varieties and the appeal of future transport sharing.

The report first presents a typology of shared travel to demonstrate its diversity, treating it as a multifaceted set of modes that meet the needs of different people at different times. We then present critical, but often overlooked, characteristics of types of sharing and technology that have implications for how people perceive and use different shared travel modes. This is followed by a model of shared travel decision-making that emphasises its sociotechnical and longitudinal nature, showing how sharing evolves over time and in unison with technology. The report concludes by considering how future developments such Mobility as a Service, autonomous and connected vehicles and wider social change may shape the future of transport sharing.

The key conclusions are as follows:

- Transport sharing is diverse in mode and in form, as well as in the degree to which technology is involved. Any attempt to understand or manage shared travel through policy must take this diversity into account, rather than treating it as a single phenomenon or mode. In particular, we identify a distinction between third-party services providing access to transport services (e.g. bike share), and those that require peer-to-peer coordination for joint travel. Currently, the opportunities for growth in third-party services look substantial in the light of increasing urbanisation, falling take-up of personal transport in younger travellers, and the introduction of automation. The complexity of negotiating trip logistics, and the need to embed shared travel within existing social and organisational groups, mean we predict only modest growth, if any, in peer-to-peer services.

- The overwhelming evidence is that travel choices do not conform to traditional models of rational analysis. Instead, they are influenced (particularly in the case of single-occupancy vehicles and private ownership) by affective influences (i.e. influences on our mood and emotions), by logistics and flexibility and, in peer-to-peer travel sharing, factors of trust, and sharing of personal space. Decisions are also heavily influenced by habit, where habit reflects strategies to deal with the day-to-day constraints of any household or living situation. Any approach to encourage shared travel should reflect these complexities rather than simply present arguments based on cost–benefit analysis. The evidence is also that environmental motivations have only a limited role, if any.

- People's lives are diverse, varying in terms of demographics and life course. Specific life events, such as having a child, or relinquishing a driving licence due to old age, have a profound effect on travel choices. Shared travel is sociotechnical. It reflects the environment in which it is being used, and the nature of any organisational or social context in which it is embedded, for example in ride-share schemes within organisations. Importantly, integration with public transport is the backbone of shared travel. Policy and strategy should be targeted to reflect local and regional constraints. Multiple types of scheme may be needed to reach out to different segments, although care must be taken to ensure that these do not present a crowded or confusing travel marketplace.

- There is an ICT aspect to many shared travel schemes, for example to support access to services and peer-to-peer matching. The evidence is that the user interface is critical to supporting understanding of the shared service and to building a mutual relationship of trust between sharers. User-centred design must be embedded in the technology. In addition, the role of human capital to facilitate and promote shared travel, particularly for peer-to-peer services, should be factored into any plan if sustainable adoption is to occur. This can be supported by having interoperable underpinning ICT infrastructure, for example to support a single-payment platform across travel modes, or to integrate shared travel into multi-modal journey-planning apps.

- The decisions and practices around shared travel are dynamic. They evolve with practice and experience, which are amplified when people have to build peer-to-peer relationships. Shared travel schemes have a high degree of failure, even if they show initial promise and success. Policy, strategy and funding for shared travel should not look to support only an initial launch, but help to nurture and grow a user base (and positive attitudes) over time.

- Much shared travel is still informal and invisible, particularly in peer-to-peer relationships. Even when those relationships have been encouraged and mediated through technology, people have a tendency to go 'offline' to continue those sharing relationships. Therefore, evaluation and measures of success should be careful to seek out data on these 'hidden' shared journeys, and be wary of comparing shared travel models where access to reliable usage data varies.

Contents

1. Introduction

Shared travel falls on a continuum between the fully private (e.g., a private car operated by its owner) through to the fully public (e.g., purchasing a ticket for a train). While these two extremes dominate most travel use in the UK, new forms of transport and travel sharing are emerging that may have value in reducing congestion and meeting environmental goals, while at the same time improving the quality and breadth of mobility available to individuals. In many cases, these may combine some of the respective benefits of private and public transportation. For example, a ride-share[1] scheme may allow a rider to cover a route that is not available on the public transport network, while reducing the costs that would otherwise be incurred through private ownership of a vehicle. From a wider policy perspective, there is both a motivation to reduce the number of vehicles on the road for reasons of congestion and emissions, and to make better use of spare capacity, particularly during peak periods (Caulfield, 2009). Single-occupancy vehicle (SOV) trips may run as high as 85% of commuting trips and 83% of business trips by car. The average single-occupancy figure for all car trips was 60% (DfT, 2011), a figure that remains broadly consistent, with more recent data showing that roughly twice as many miles are travelled as the driver of a car or van than as a passenger in a car or van (DfT, 2016), suggesting that there is substantial untapped capacity in vehicles. Furthermore, implementing shared travel schemes may be relatively cheap in comparison with building new road infrastructure (Fellows & Pitfield, 2000). Finally, sharing in general has a range of positive and appealing pro-social connotations and indeed, for many modes of transport, sharing travel is a behaviour that many people already exhibit informally, with families and friends (Morency, 2007), or within specific groups with limited access to transport, such as older, rural or migrant communities (ITP, 2010; Lovejoy & Handy, 2011; Musselwhite & Shergold, 2013). This pro-sociality also appeals to wider notions of the shift from ownership to access, supported by peer-to-peer networks and collaboration (Botsman & Rogers, 2010).

ICT, by widening the breadth of communications and providing a mechanism for coordination, plays an important role in facilitating greater adoption of travel sharing (Gärling et al., 2004; Buliung et al., 2010; Firnkorn, 2012). Innovations such as on-demand ride sharing or GIS-supported cycle hire, which were once the subject of research (Calvo et al., 2004), have transitioned to widely available live schemes[2]. We also note emerging successful schemes in countries such as Germany (Kopp et al., 2015) and Denmark (Transport Research, 2015) in areas such as car pooling and short-term car hire, both in their own right and integrated as part of Mobility as a Service (MaaS). Advances in mobile networking technology and the widespread adoption of smartphone-type devices have generated interest in concepts such as

[1] The UK has an unconventional use of terminology. In most countries, ‘car sharing’ refers to the use of a pool car using a short-term hire scheme such as through a car club (Kopp et al., 2015). Giving someone a lift in a private car is referred to as lift sharing or ride sharing or even (confusingly!) car pooling (Morency, 2007). For clarity, we refer to giving someone a lift as lift sharing or ride sharing, and refer to shared access to a vehicle as a car club. It is important, however, when reviewing literature from other countries, to take the different nomenclature into account.

[2] For example, www.liftshare.com; www.santandercycleslondon.co.uk

'real-time' or 'dynamic' ride sharing, which exploit digital ubiquity to offer on-demand trips in response to requests made at a specific time and place (Wash et al., 2005; Shao & Greenhalgh, 2010; Kopp et al., 2015). Finally, the rise of social media platforms such as Facebook and Twitter presents further opportunities for travel sharing based around disparate online communities rather than those formed around, say, a specific workplace (Chaube et al., 2010). This is important because successful adoption and sustainability are not just a question of providing the right vehicular infrastructure, but also providing the right ICT support, built environment infrastructure and human capital to support such services.

This report compares different forms of shared travel, exploring the human motivations and decision-making that drive it. It constructs a framework of travel sharing, with a human-, user-centred philosophy at its heart. The role of human factors as an applied science is to understand the considerations that shape both the needs and the abilities of a user when they interact with a service. These needs and abilities include:

- **physical factors:** physical mobility, in relation to the ability to use a mode of transport, or potential reliance on others due to disability; also physical and life-course factors such as ageing that might impair the use of associated technology such as shared travel apps

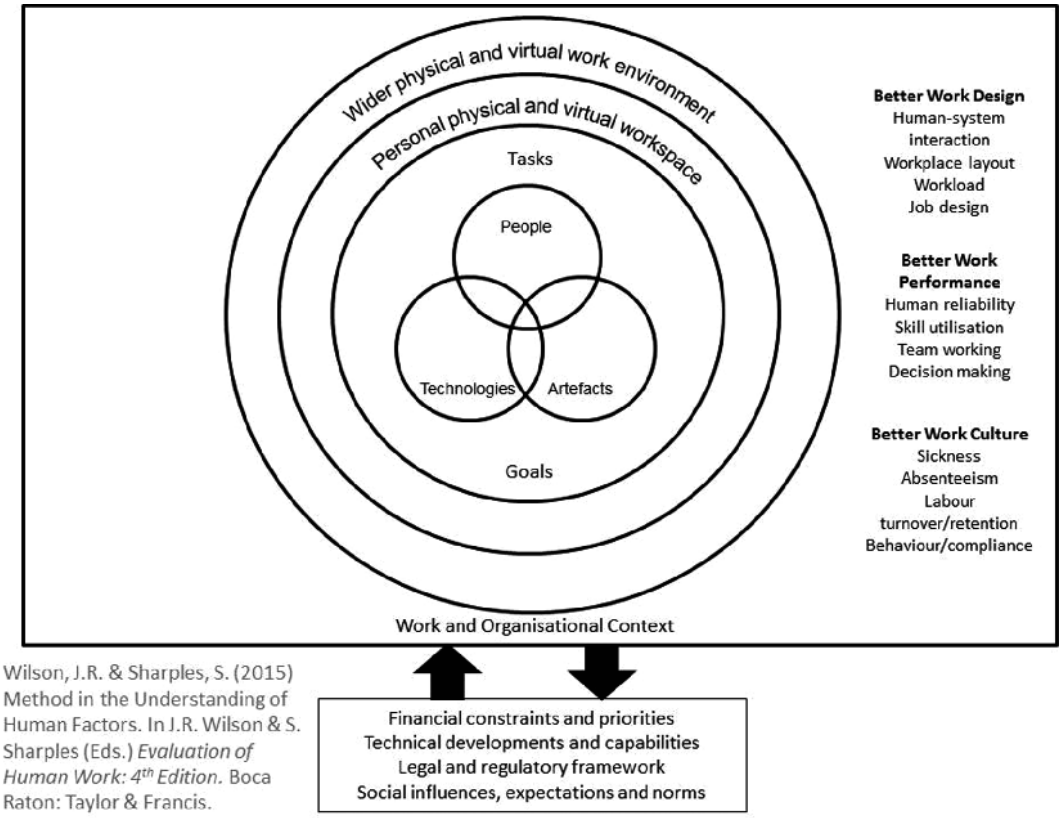
- **cognitive factors:** user perceptions, expectations, knowledge and the cognitive capacity to perform certain tasks (e.g., does a service provide adequate situational awareness of the current availability of shared travel?, can users understand the representation?). The cognitive nature of sharing is particularly important as it emphasises how decisions are made, and the factors that influence perceptions, which go beyond purely instrumental decision-making

- **organisational and social factors:** derived from the social setting of an action, these factors might be a physical organisation (e.g., shared travel in a workplace), or an 'organisation' with a looser structure, such as a community, or a social network of users of a sharing service (Chaube et al., 2010). For shared travel in particular, organisational factors influence perceptions of trust, communication and collaboration, which are vital when setting up sharing relationships; norms or expectations for sharing may well be set within a community rather than in terms of individual decisions (Harvey et al., 2017)

We stress that these factors are highly interdependent – the nature of an organisation will influence my personal perceptions of who I trust and therefore who I am likely to share with, and my physical requirements may influence what kind of shared travel I am able to use. These factors are typically viewed in a multi-layered configuration (Sharples & Wilson, 2015; see Figure 1), where a user interacts with technology and artefacts in a work (or task) setting, an organisational setting, and a social setting that places both demands and norms on any interaction. Also, these factors are dynamic, in that they change over time. For example, people's attitude to a service changes as they understand more about it, gain familiarity with it and learn how to use it more effectively, in ways that are not always as the designer had intended.

The human factors approach traditionally comes from an engineering and psychological perspective. However, the active participation of stakeholders as both users and custodians in design (Haines et al., 2002), the importance of personal perspectives and practice (Kurup et al., 2017), and the insight that context is not merely background but plays an active role in shaping activity (Hoffman & Woods, 2000) mean the approach reflects emerging perspectives in transport and mobility (Shove, 2010; Middleton, 2011; Schwanen et al., 2011) that challenge notions of rational decision-making, and quantitative modelling, in the study of transportation.

Figure 1: An 'onion model' mapping the scope of a sociotechnically informed human factors perspective



Wilson, J.R. & Sharples, S. (2015) Method in the Understanding of Human Factors. In J.R. Wilson & S. Sharples (Eds.) *Evaluation of Human Work: 4th Edition.* Boca Raton: Taylor & Francis.

Implications

We take the view that shared travel is a sociotechnical phenomenon (Buliung et al., 2010), in that it reflects not just the transport technology itself, but also the personal and social context of the sharer and, particularly with newer forms of sharing, the technology that underpins the sharing mechanism. This demands that the design of sharing systems, and the policy supporting them, take a user-centred view that seeks out physical, cognitive and organisational factors that will influence decision-making and therefore the potential success of the system.

This user-centred approach needs to specify not just the design of the core transport technology, but the supporting infrastructure, ICT and usability, and processes and human capital, all of which have been identified as important to successful sharing. The rest of this report will explore what these factors are, and how they vary for different types of shared travel, user and setting.

2. A typology of travel sharing

Research in the literature typically focuses on only one or two types of transport, usually the car (Morency, 2007; Sun et al., 2012; Koch et al., 2015) and less frequently, bicycles (Fishman, 2016; Sun et al., 2017), often drawing comparisons between a given shared mode and a baseline of private ownership. Integrative overviews across multiple shared modes are, by contrast, relatively rare. This is unfortunate, since such a framework would support contrasts and comparisons between shared modes, especially as some examples of shared travel systems have similar characteristics across modes: for example, a free-floating car club and free-floating bike share both provide access to shared transport without fixed docking/parking stations. Of course, other forms of sharing may be more influenced by emerging technologies than others. For example, we later argue that autonomous vehicles will have a positive role in car clubs in comparison with lift sharing, and may be more appealing to different demographics (Kopp et al., 2015) and so require different policy and incentivisation measures.

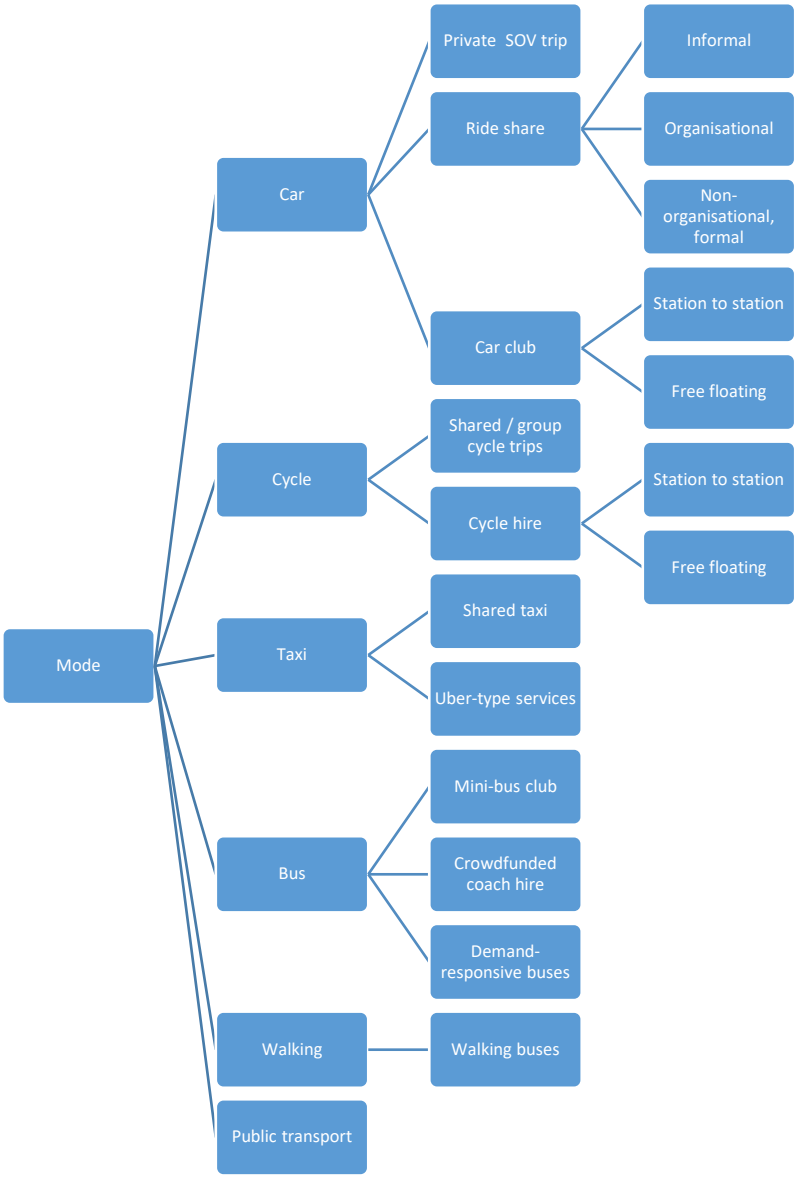
The full typology is presented in Figure 2; as a contrast we offer discussion of two, non-shared forms of travel:

- **private single-occupancy vehicles (SOVs):** private vehicles used for personal trips by one person; this could be a bike or motorbike, but the major focus is SOV trips in cars, which use road capacity and generate emissions (Caulfield, 2009)

- **public transport:** while shared in terms of space (including use by groups), public transport is not strictly shared as there is no specific need for users to collaborate or coordinate to access the resource. It is, however, important to consider this in the wider discussion of shared travel as there is a concern that decisions to use shared travel resources such as car-club schemes can reduce patronage of public transport rather than reducing private car use (Firnkorn, 2012)

We acknowledge there are other forms of exclusive, or non-shared, travel: walking, cycling and co-modal journeys. We choose these two forms of exclusive travel as our contrasts because (i) SOV car trips are generally perceived as both the highest source of environmental and congestion impacts, and the greatest source of untapped capacity on the roads; and (ii) as noted, public transport is perceived as being at risk of cannibalisation by shared modes (Firnkorn, 2012).

Figure 2: Common shared travel modes



Many attempts to shape journey and mode choices are based on an assumption of rationality on the part of the car driver. On the whole, this translates into an assumption that drivers base journey choices on cost (financial, time, reliability etc.), referred to as instrumental factors. These instrumental factors do play a role – for example, in a survey of commute choice, Shannon et al. (2006) and Malodia and Singla (2016) found that time rather than cost was the major barrier to changing from a car to an alternative mode of transport. However, efforts to influence behaviour based purely on cost and timing information (e.g. indicating that a public transport alternative is cheaper and/or quicker) have failed to have a significant impact on driver behaviour (Kenyon & Lyons, 2003).

In practice, a number of additional and potentially potent factors also shape behaviour. The first of these are symbolic-affective factors. These refer to the potential of a transport mode to convey an image such as status or desirability about the transport user (symbolic) and also to elicit emotional (affective) responses in the

user such as freedom, individuality and comfort. Cars are often related to personal trajectories, success and careers, acting as symbols of wealth and status (Steg, 2005; Jensen, 1999). This is more than just the symbolic nature of the car itself; positive aspects of the journey experience, and perceptions of personal space, autonomy and control, may all be influenced by use of the car.

Mann and Abraham (2006) point out that there may be a blurring between affective and instrumental factors. For example, the 'freedom' of the car (potentially a symbolic-affective factor) is rooted in the desire to have flexible timing, control over the travelling environment, and freedom to spend time on one's own. That said, many instrumental factors also have a highly subjective dimension that may be hard to disentangle. Car drivers are likely to overestimate public transport times, and underestimate car journey times, and travellers tend to see public transport as a series of discrete, often negative episodes, whereas car commutes are viewed in a more homogenous manner (Mann & Abraham, 2006). It is also important to view time not just in terms of arrival (i.e., punctuality), but in terms of the effort of longer journeys, or the stresses of coping with delays, and this too can have an emotional content (for example, where people describe train delays as a 'nightmare').

Kenyon and Lyons (2003) found that as well as reasoned perceptions of modes, many other perceptions were highly subjective, such as the feeling of control engendered by driving as opposed to taking public transport. These perceptions appeared 'intrinsic and subconscious. They are rarely acknowledged and thus remain largely unchallenged' (Kenyon & Lyons, 2003, p.16). Affective factors may also be reported less frequently because people are often aware of the social cost of car ownership and are therefore self-conscious about reporting such factors (Steg, 2005). Indeed, even those who are less overtly motivated by status may see the dysfunctional aspects of cars as themselves symbolic; a second-hand car may indicate frugality, an unwashed car may imply a busy lifestyle (Mann & Abraham, 2006).

Finally, car use and the choice of routes driven are heavily influenced by habit (Bamberg et al., 2003; Kenyon & Lyons, 2003; Seethaler, 2004), with people bound into routine commuting patterns by choice of lifestyle such as where their home is in relation to work (Lyons & Chatterjee, 2008). This may in part be influenced by a lack of knowledge and, more specifically, experience of the alternatives (Brown et al., 2003). In terms of the route choice, people will often adhere to suboptimal routes, even when they are aware they are suboptimal, in order to save effort or reduce risk (Van Excel & Rietveld, 2009).

In contrast, general experience (or lack of experience) in using public transport may inhibit its use. This is possibly in part through knowledge and confidence (Brown et al., 2003), and in part through knowledge of timetable and service patterns (discussed below). Kenyon and Lyons (2003) found that reasons for not wanting to use public transport included an inability to trip chain[3], and a preference for door-to-door travel. These factors for public transport may well transfer across to shared travel. It is important, however, not to view habit as an external factor that bears down upon travel choices as a constraint on transport decisions (Shove, 2010).

[3] That is, a trip between two places, such as home and work, that has an intervening stop

Rather, habit is an integral part of the practice of undertaking a journey. This practice extends to include how the journey fits and is shaped by the life and context of those undertaking the journey (Shove, 2010; Middleton, 2011) and therefore travel habit is both personal and dynamic, reflecting both microscopic changes to specific journeys, and macroscopic changes to people's lives and the changing context of their journeys.

Whatever the character of affective and habitual choices, the end result is that people may follow a course of action with a single mode far beyond the point where it would appear to make sense as a rational calculation and therefore, what economic modelling alone might imply. For example, Mann and Abraham (2006) cite respondents who would sooner move home than take public transport, and sooner have less money. Therefore, the influence of habit and affect may constitute persistent and deep-seated factors in shaping mode choice that are both more important and yet more difficult to quantify and address than purely rational factors. Affective factors may be more important with leisure trips, where flexibility and 'no stress' have an even greater role to play (Anable & Gatersleben, 2005).

At this point, it is also worth noting that there is evidence that younger, particularly urban, travellers may *not be acquiring the habit of driving* in the same numbers that were found up to a peak in the growth of driving and driving licence-holding in the period 1992 to 1994 (Chatterjee et al., 2018). Whether this reflects a genuine change in attitudes and values towards driving itself is debatable, since this trend exists against a backdrop of general decline in travel in general (counted as trips taken), with only modest compensatory increases in walking and public transport use; it is more likely this reflects deeper underlying changes in the structure of work and life patterns.

Implications

Shared travel must be seen against a backdrop where private ownership, and single occupancy, are seen as the predominant and preferred mode of travel. Policy efforts to encourage a move away from private, single occupancy trips, should look at least to appeal to the symbolic nature of travel that reflects the nuanced appeal and practicality of cars, rather than appealing to purely objective rationality. Schemes that still involve the use of the private car, or suggest an occasional alternative to the private car, may be more effective than trying to encourage a wholesale shift. However, we also note the emerging opportunity (and even necessity) of encouraging shared travel, and supporting travel-sharing initiatives, in a new generation of travellers who have less capacity and interest in owning a car.

Car-based sharing

Ride sharing

Ride- or lift sharing involves one person giving another person or people a lift. This can vary from householders giving lifts to each other (the 'school run'; see Morency, 2007) through to fully organised and monetised lift-sharing schemes (such as BlaBlaCar). We categorise lift sharing in three ways:

- **Informal:** Informal lift sharing takes place without a formal arrangement. It may be a one-off or repeated over time as an ongoing relationship. It may always be the same driver and passenger, particularly when the passenger is being driven because they are not able to drive themselves, or there may be turn-taking. It may be within a household, in which case the opportunity to give someone a lift may generate rather than reduce trips (Morency, 2007). It may also happen at a community level (Lovejoy & Handy, 2011). If we take the figure that 60% of car travel is through a single-occupancy vehicle (DfT, 2011), then 40% must be shared and, even within the growth of other forms of ride share, this proportion must be dominated by friends, family, colleagues and so on sharing journeys.

- **Organisational:** Organisational lift sharing is formalised but occurs within existing groups of people, and is typically formally arranged or sanctioned by an organisation. The most prevalent example is the workplace ride-sharing scheme (Buliung et al., 2009; 2010; Golightly et al., 2010), though schemes may be organised for other groups such as churches, hospital visits and healthcare, and sporting clubs. Examples are Nottingham University and Newcastle football supporters (Nottingham University, n.d.; Altoonativetravel, n.d).

- **Non-organisational, formalised:** The third form of lift sharing is non-organisational, in that it does not necessarily take place within an existing group, but is organised through a formal scheme. This is an excellent example of a scheme that has become much more viable through the availability of technology. In some cases, such as Liftshare, services can be repackaged to support organisational lift sharing. While such systems have flourished for longer trips, on-demand ride-share schemes have been touted for some time as a transport panacea but with few successes, at least in the UK. Examples are the companies Liftshare and Blablacar (n.d.).

Car clubs

For the purposes of this framework, ‘car-club’ (and again, note that outside the UK these may be referred to as ‘car-sharing’) schemes give the user access to a vehicle. This is something of an extension of the ‘departmental car’, where organisations or departments would buy or lease a ‘pool car’ for any member of an organisation to use for business trips. In the current and proposed future context, car clubs may also arise for private use, where the actual owners of the asset are typically a third-party organisation. In Germany, for example, this can be major car manufacturers (Daimler, Mercedes-Benz). Overall, this reflects this different models of car-club schemes – for-profit, non-profit, cooperative (owned by its members), and university research programmes (Shaheen et al., 2009). An example is Car Next Door (n.d).

A variation is station-to-station car clubs, which involves short-term car hire for a journey between fixed points. The user may be able to use the car for a single trip and dock it at a different station from pick-up, or is obliged to return the car to the origin station (Shaheen et al., 2009). An example is Co-Wheels car club (n.d.).

Finally, in free-floating car clubs, the user is able to book the car for pick-up and drop-off at any point. These schemes have proved most viable in urban centres, with

examples of successful use in a number of countries including Germany (Kopp et al., 2015). An example is Daimler's Car2Go scheme (n.d.).

Taxi-based sharing

Shared taxi services such as Splitcab involve being able to book or use a taxi with other users. Such schemes have been popular in places such as airports, and can be actively managed by taxi marshals, though there is some interest in the use of technology to coordinate taxi sharing (Sun et al., 2012).

On-demand mobile-enabled services such as Uber allow private car owners to offer themselves as a taxi service. Cities and countries vary in the amount of regulation demanded of drivers.

Cycle-based sharing

The primary focus for cycle-based sharing has historically been short-term cycle hire, which, as with car clubs, can be both station to station or free floating. In the former schemes, cycles can be picked up at fixed docking stations, an example of which is the 'Boris bike' scheme in London (currently sponsored by Santander), though similar schemes are now common in many cities (Goodman & Cheshire, 2012).

In free-floating or 'dockless' cycle hire, cycles are available at point of need, and can be dropped off anywhere that a traditional cycle can be left. Ofo are an example of this (n.d.).

An additional form of sharing with bikes is when cycling in groups, for example when parents and children go on a shared cycling leisure trip.

Bus-based sharing

Bus-based sharing has a long history, for example through traditional mini-bus hire by a club, school or group of friends. More recent variations include crowdfunded coach hire, where previously unrelated supporters with similar journey requirements create a critical mass sufficient to pay the cost of coach hire. For example, Sn-ap (n.d.) matches people who want to make similar journeys with coach operators. Finally, demand-responsive buses provide a dial-a-bus service as an alternative to scheduled bus services.

Walking

Finally, we include walking. This is an activity that has a multitude of ways and motivations for sharing, either as a practical measure (e.g. to escort children to school), or simply for the act of spending time together (Middleton, 2011). While we would rarely think of walking as being formally shared, there are settings where this might take place. Of particular interest are walking buses (Kingham & Ussher, 2005) – coordinated walking groups that are primarily used to take children to and from school in a group – in part because they demonstrate planned sharing within the walking context, but also because some of the complexities and constraints found in

other shared modes, such as the importance of human capital, are found in walking buses.

As already indicated, sharing can cover a wide range of human behaviour and considerable creativity can be shown in inventing new formal and informal arrangements. Consequently, it has been necessary to exclude certain forms of activity to make the present taxonomy workable.

Out of scope for this shared travel framework are conventional hire-car services (e.g. a standard car-hire agreement such as those offered by Hertz, Enterprise etc.). We also treat shared, private ownership (e.g., where students club together to buy a second-hand car; see Golightly et al., 2010) as out of scope.

We have only focused on the mode of travel being shared in some form. However, the reason for travelling, and accommodation for travel can also be shared. High-profile examples of this include CouchSurfing and Airbnb. These are also considered out of scope for the current review.

Also, out of scope for this report are shared information and crowdsourced information regarding travel. This includes use of Twitter or review services such as TripAdvisor, which carry shared or volunteered information about both the destination *and* the mode of travel.

There are other ways that travel can be shared, such as family railcards where group travel is incentivised, sharing of train tickets (e.g., someone at work emailing colleagues to see whether they have a spare, unused train ticket) or other arrangements for groups hiring a bus on a conventional basis. These are currently considered out of scope, as they are modes that are currently shared as part of conventional use. While crowdfunding for coach hire has been considered, we consider crowdfunding for buying a coach (for example, by a charity) as out of scope. We consider the hire of commercial vehicles, such as pay-as-you-go vans, or the use of services such as Taskrabbit or Gumtree to secure van hire, or sharing services where one part may be offering transport, to be out of scope.

That said, the taxonomy presented in this report should be treated as evolving over time as either some of these other forms of sharing grow in prominence, or new forms of sharing come to light.

Implications

Shared travel is not a singular thing, but a highly diverse set of travel modes. From a policy perspective, it is questionable whether these modes should be treated singularly, or handled through separate policies to reflect that diversity, and this is not necessarily just between underpinning mode (car, bus etc.). One division that we will return to again in this report is between services that are operated by a third party, giving people asynchronous access to a travel resource (such as cycle sharing), and those peer-to-peer services where people need to collaborate to access a travel resource, which may or may not be owned by one of the people involved (for example, lift sharing).

3. Mode characteristics

In Table 1, we offer a summary of each mode, characteristics of the user base where known, and indicative data on adoption. We also comment on the quality of the data relating to current levels of adoption. Specific figures about the use of various shared travel modes are often sparse for a number of reasons: the high number of smaller, local schemes rather than a single national scheme; the mix of public and private schemes; the number of emergent and/or undocumented schemes; and the number of personal and non-recorded sharing arrangements (Morency, 2007; Harvey et al., 2018). Lift sharing in particular has been referred to as the 'invisible mode' (Chan & Shaheen, 2012). If this is apparent for shared car travel, it becomes even more present when we consider sharing arrangements for modes such as cycling and walking, where sharing takes place on a highly informal basis. That said, this sharing is not 'unstructured', in that behaviours can be quite routine and also reflect the life and practical constraints of the people involved, such as the ways in which households or partners manage their responsibilities and mobility in response to the demands of work, school or leisure (Shove, 2010; Middleton, 2011; Rau & Sattlegger, 2018).

However, there is also a more overriding issue, in that the current level of adoption of formal shared travel modes is generally low. In a study in the Netherlands of attitudes to shared ownership in general, only 0.2% had used shared travel – in this case, formal lift sharing and without any data on whether this was repeated use or just a one-off. This study also found that, in general, younger and low-income groups are more economically motivated to use and provide shared assets; younger, higher-income and higher-educated groups are less socially motivated; and women are more environmentally motivated. Furthermore, peer-to-peer situations using different types of shared assets appear more economically than socially motivated to offer access to shared assets (Böcker & Meelen, 2017), with similar results in a diary study of the propensity to lift share (Cranwell et al., 2011).

The numbers in Table 1 serve as a baseline for considering potential increases (and decreases) in shared transport usage. However, as covered in subsequent sections, the factors that influence uptake in shared travel will be as much influenced by forms of exchange and sharing, technology and contextual drivers as by the mode itself. We therefore discuss these factors before giving some predictions of shared mode use in the conclusions to the report.

Table 1: Summary of shared travel modes

Mode	User characteristics	Adoption rates	Measurement challenges
Lift sharing	Greater adoption in suburban areas; providers more economically minded than users; as likely to appeal to women as men; more appealing to older users	7,000 members of Heathrow lift share with over 2,000 members confirmed as sharing on a regular basis (Transport Extra, 2016); BlaBlaCar has 35 million users in 22 countries (BBC, 2017); if 60% of car journeys are single occupancy vehicles then 40% must be shared in some form (DfT, 2011)	Informal lift sharing is not visible; many lift-sharing arrangements through formalised schemes are taken offline and are no longer visible; while case studies can give an indication of registered users who regularly share, getting formal numbers of regular, continued shares, and their frequency, can be difficult to acquire (i.e. schemes may be more successful than they look through data)
Car clubs	More likely to appeal to urban users and male users; replacement for a second car; affluent; 20–40-year-olds	Zipcar has 1 million users (Zipcar, 2016); across the UK, car clubs have over 207,000 members with over 3,600 vehicles (Carplus, 2016)	Tends to be commercial data; schemes give worldwide adoption rates
Cycle sharing	Two major groups – male, 20–40-year-olds, and urban living; affluent areas; also younger, less affluent users as an alternative to ownership	Adoption of schemes (docked and dockless) across the UK and worldwide; London Santander bike scheme has 600,000 registered users undertaking 10.3 million trips in 2016 (TfL, 2017)	Rich data source generated by schemes run in the public sector (e.g. cycle-sharing scheme in London)

Taxi sharing	Almost no data – potential for informal arrangements between travellers between common and anonymous locations (e.g. airport to conference centres; airport to hotel; taxi rank to approximate locations)	No records of at-scale systems	Few schemes and little or no public data
Bus-based sharing	Typically either public schemes (e.g. to increase access to services such as hospitals) or for rural areas; some examples from outside the UK of other types of services	Approximately 5 million community bus journeys in England 2015/16 (DfT, 2016a); schemes implemented or planned for 30 Chinese cities	Diverse schemes; usually local, community- or charity-based (e.g. www.bactcommunitytransport.org.uk); no data at scale; less stringent reporting requirements than conventional bus services

Lift-sharing data tends to be older, reflecting the longstanding presence of non-technology-based schemes, but overall painting a slightly different picture of sharing than that which applies to other forms of travel. First, lift sharing appears to be as popular with suburban travellers (Teal, 1987; Ferguson, 1995; Buliung et al., 2009) as it is with urban users (Delhomme & Gheorghiu, 2016). This appeal in the suburbs reflects both higher existing car ownership (and therefore availability of cars), and also a combination of travel demand to get to work and lower availability of public transport for suburban areas. There are also some indications (Buliung et al., 2009; Delhomme & Gheorghiu, 2016) that lift sharing is more attractive to female users, and to older users, therefore suggesting a slightly different demographic from cycle sharing or car clubs. More recent work suggests that popularity with female users reflects a change in access and mobility requirements, with female workers needing to travel further. It is noted, however, that work on dynamic ride-share apps is sparse at this stage (Dickinson et al., 2016), though one potential differentiator between conventional lift sharers and dynamic lift sharers is those with fixed shifts versus those on flexible working hours (Dailey et al., 2001). Finally, we note again that there might well be demographics that are dependent on lift sharing, but this typically occurs at a more informal, non-technological level, for example in the USA with poorer Hispanic communities (Lovejoy & Handy, 2011) or older, rural users (ITP, 2010).

Car-club use is adopted by different socioeconomic groups for different reasons (Costain et al., 2011), whether this is because they are more environmentally conscious (Costain et al., 2011) and/or because of less access to a vehicle. However, the more cars a family has, the less likely they are to stay in a car-club scheme (Habib et al., 2012). The use of a car-club scheme may obviate the need for a second or third car (Kopp et al., 2015). Both free-floating and station-to-station car-scheme users are more likely to be urban based, in contexts where there is strong public transport (Costain et al., 2011; Kopp et al., 2015). However, station-based sharing is currently more pay-as-you-go, whereas free-floating schemes are through ongoing subscription (Kopp et al., 2015) and as a result, users of free-floating car clubs tend to be more affluent males.

Cycling-sharing schemes have been something of a success story. The period 2010 to 2016 saw ‘Boris bikes’ (now sponsored by Santander) increase from 100,000 users (Ogilvie & Goodman, 2012) to 600,000 users and 10.3 million trips (DfT, 2017). Not only is there growth in the number of users; cycle schemes are able to show actual adoption (as opposed to, say, ride-share schemes). For docked bike-share schemes, living within 500 metres of stations can increase by three times the propensity to use the system. Whereas schemes based around employment rather than residential areas may see lower adoption (Fisher et al., 2014). Motivations vary for using cycling schemes, but when income is lower, cost savings are more likely to be forwarded as the reason for using the scheme (Ogilvie & Goodman, 2012). Overall, however, cycle sharing appears to be an infrequent adjunct to other forms of travel, with reports of as many as 50% of users actually taking a cycle-share journey once a month or less (Fisher, 2016). Cycle sharers tend to be wealthier, although (in London at least) the number of users from less affluent areas has increased over time (Goodman & Cheshire, 2012). Cycle sharers are also more likely to be male and white, though to a degree this reflects general patterns of cycling (Fishman, 2016).

Data on taxi sharing is non-existent and IT-based schemes to facilitate it tend to be either conceptual proposals or have only been tested using modelling or simulated data (d'Orey et al., 2012; Ma et al., 2015). Early work on user requirements (Xu et al., 2012) suggests some opportunity for shared taxis, but the need for safety, trust, anonymity and coordination of fare sharing means it is best applied to trips where both the start and end are anonymous (e.g., from an airport to a conference centre) rather than between private residences.

Data on bus-sharing schemes is also sparse, though there is some data for schemes outside the UK. For example, there were, as of 2015, schemes in 22 Chinese cities (Liu & Ceder, 2015). Despite the potential for schemes to support rural areas, data from China suggests that schemes are most common in more affluent, urban environments where the adoption of technology is high. Community and on-demand bus services accounted for approximately 5 million journeys in England in 2015/16. Local authorities indicate that community transport services operate for those who cannot use conventional bus services, such as older people or people with disabilities, and also in areas that conventional services do not reach, such as rural communities (DfT, 2016).

Implications

The research literature to date on car clubs, lift sharing and cycle sharing is considerable. There are indications of clear demographic trends and differences within the overall pool of shared travel modes. We note, however, that it tends to focus on quantitative data on adoption, demographics and journey type, and says very little about the nature of sharing or the role of technology (see below). Also, there is a growing base of literature that highlights that these decisions are not abstract, but reflect the choices and practices of mobility that in turn reflect the lives and nature of the people involved. We also note that research data on more diverse forms of travel (e.g., crowdsourced bus hire) is sparse. These characteristics must be taken into account when considering the existing literature and evidence.

Different modes appeal to different demographics and therefore need appropriate incentivisation and targeting. The appeal to, and disposable income of, urban males gives them a preference for schemes that offer them access to a shared asset provided by a third party, for a cost (car-club schemes and so forth). However, feelings of insecurity that make informal ride sharing less attractive suggest that such schemes may be more appropriate for non-urban environments and, potentially, female users. However, the diversity of shared services means that mapping between different modes and segments is both complex and approximate, and further research is needed to reflect newer demographic trends.

Many types of scheme have little or no data associated with them, either because they are inherently informal or because users take their interactions offline. This means that evaluation is challenging. Careful consideration for peer-to-peer services is needed and these cannot be readily compared with services such as cycle shares, where all transactions and trips are logged.

Demographic frameworks and life stage

Based on the framework above, it is possible to apply different types of shared travel model, and the overall appeal of shared travel, to a demographic framework such as the DfT's segmentation study *Climate Change and Transport Choice* (2011) (Table 2). While out of scope for this report, this could be repeated for other taxonomies of traveller type (Anable, 2005; or results of the Transport Systems Catapult Traveller Needs study: Transport Strategies Catapult, 2015). The third column in Table 2 offers some tentative interpretations about the fit between the needs and existing habits of these demographic groups and the features of various shared transport modes, accepting that, as already discussed, decisions to change our use of transport, and especially, to share, are grounded in a wide range of variables beyond the instrumental and purely rational. It must also be conceded that demographic segmenting necessarily leans towards the general and the stereotypical and that these general indications will not necessarily be accurate for all members of these groups. For example, while it is reasonable to think 'older sceptics' will lack interest in cycle sharing as a group, clearly this will also encompass some existing recreational cycling enthusiasts who may have a very different view.

Table 2: Traveller demographics and suggested match with types of sharing

Demographic group	Characterised by	Potential transport-sharing implications
Older, less mobile car users	Low mileage; limited concern for environment; likely to have mobility issue(s); less likely to cycle	Could use shared travel, especially lift sharing within the community; unlikely to use shared cycling schemes; less likely to use public transport-based schemes because of mobility limitations
Less affluent urban young families	Urban living; lower education; have children; amenable to cycling	Could use shared cycling schemes; less likely to lift share as they need space of whole car; more likely to use car club; less affluent, therefore more likely to pay on demand rather than subscription

Less affluent older sceptics	Low income, low education; unlikely to cycle	Unlikely to have interest in cycling schemes (unless existing interest in cycling), possibly could lift share; possibility of reduced tech competence, limiting access to such schemes (Barnard et al., 2013; Netimperative, 2016); less affluent and so more likely to pay on demand rather than by subscription
Affluent empty nesters	CO_2 influenced; likely to have a second car; still likely to be in work	Do not need to drive children around regularly, although have typically retained two cars anyway; sustainability aware, so may be interested in car clubs; higher education and high income mean could use online membership schemes and subscription-based schemes
Educated suburban families	Have second car; high education, high income; likely to consider running costs; likely to consider CO_2 emissions; amenable to cycling; many still have children at home	Could consider car-club option, but potential use for children means reliability and availability would have to be high; suburban dwelling means reasonable density for lift share
Town and rural heavy car users	Moderate affluence, high mileage; model and car performance important	Possibly most challenging group to approach – while there are examples of rural car clubs, town and rural heavy car users demonstrate an emotional attachment to the car (Steg, 2005); may respond to appeal of more high-performance car clubs and similar that offer access to prestige vehicles

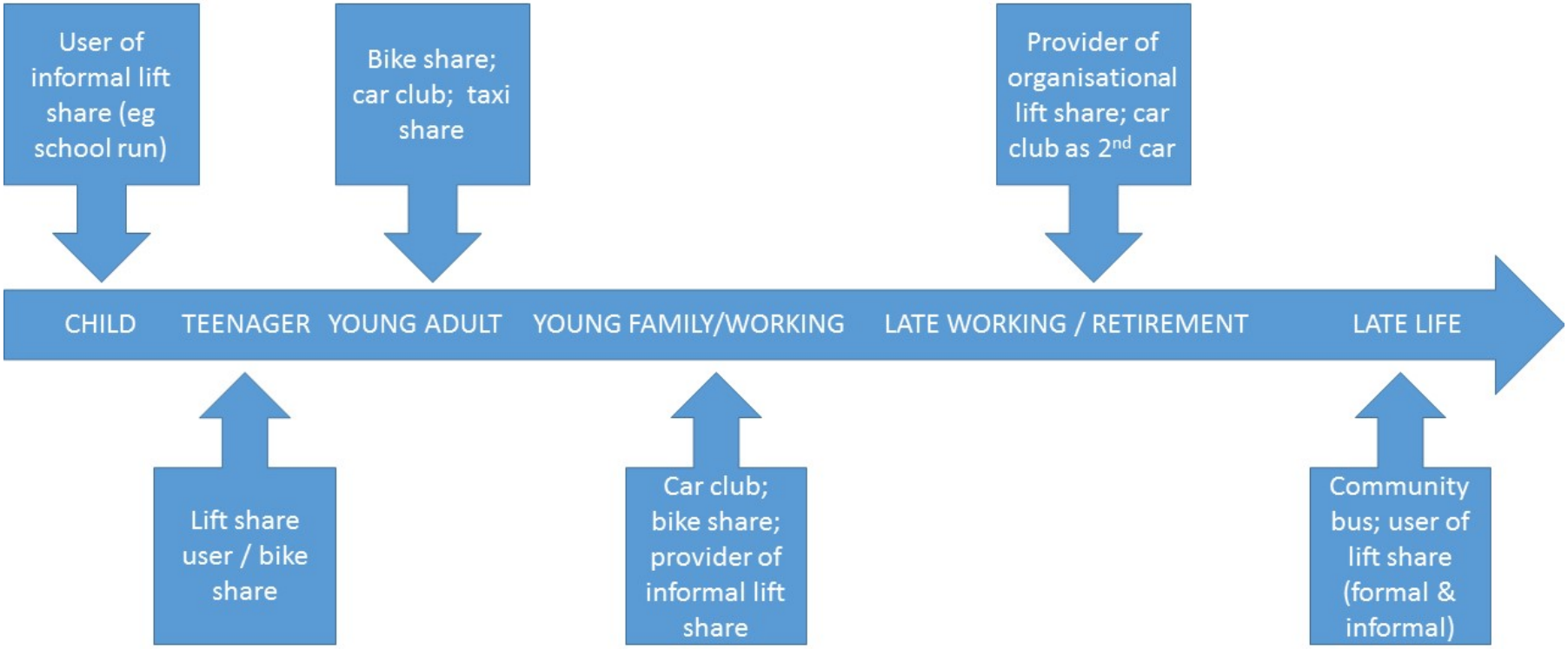
Elderly without cars	Not clear whether they cannot drive or choose not to; most likely to like the bus though not hugely; still think cars are safest	Could be recipients of lift sharing where necessary, particularly within organised schemes; users of community bus schemes.
Young urbanites without cars	Moderate education; prefer cycling to bus, but do not think it is safe; urban environment; many in full-time education	Unclear how many have driving licence; some might cycle but would need supporting information about safe cycle routes; possible users of community/on-demand buses
Urban, low-income without cars	Unhappy with public transport; likely to have family	Possibly amenable to being lift-share recipients if on their own, not with children; could use car clubs, but unclear how many have driving licences

There are challenges in mapping modes to segmentation. First, attitudes to shared travel may be as much influenced by knowledge, comfort and trust in technology (particularly if the technology is delivered by trusted brands (e.g., a future Amazon MaaS service)) as by the mode itself. Technological competency, attitudes and expectations are changing (Ofcom, 2017), although current transport-related segmentations may not take this into account (the TSC Traveller Needs Survey is an exception). Second, as we note across this report, how one approaches (and succeeds) with a new travel mode will influence how one approaches that mode, and possibly other modes, in the future, and therefore a simple segmentation based on age or demographics does not take into account people's amenability to shared travel modes as a cumulative product of experience over time. Third, major social changes, in particular migration to urban environments and access to electric (low-emission/low-cost) and autonomous vehicles will change perceptions and access to different modes. All these changes are potentially disruptive to these segmentations in the future.

As an alternative view, Figure 3 summarises the data on different shared travel modes, suggesting how their use varies over the life course. The earliest (Morency, 2007) and latest stages of life (Musselwhite & Shergold, 2013) are characterised by dependency (a need to move, not able to drive, not physically able to move unaided). The intermediate stages are those where people have both the physical ability to use modes such as bicycles (Ogilvie & Goodman, 2012), and greater interest in new modes such as car-club schemes (Kopp et al., 2015). At this point

they can potentially at least, provide access to shared modes, in the case of peer-to-peer services (Golightly et al., 2011). We note that sharing, particularly for peer-to-peer services or group travel, is reflective not just of an individual's life course but that of all the parties involved. For example, as children get older and more independent, parents will be less constrained by the need to take them to and from school. In another example, one of the reasons for difficulties in sustaining walking bus groups is that children become more independent, but the initial marketing and support are no longer present to encourage new parents to join and sustain the service (Kingham & Ussher, 2005). Also, this life-course model should only be taken as an approximation since, as well as there being gradual shifts over time, the life course is shaped by specific events (an accident that reduces mobility, the birth of a child, a change in job, for example) that have a profound effect on choices, including a need or opportunity to share (Sattlegger & Rau, 2017).

Figure 3: How shared travel might be used over the life course



Implications

The opportunity and need to share may change over the life course, but it should be stressed that rather than being a gradual, abstract change, the life course is shaped by specific events and by the changing needs and capabilities of those around a person that might choose to share. Support for shared travel must therefore reflect different needs at different life stages, but also, as life stages and events occur, match the right mode of shared travel to meet the requirements for that change, and therefore encourage a shift away from the use of private vehicles.

4. Other characteristics of shared travel services

While mode and trip characteristics are important to describe shared travel modes, there are other characteristics of shared travel services that can have a marked effect on how these services are delivered, and therefore the decision to use such services (Freudendahl-Pederson & Kesselring, 2018). We discuss two important groups of characteristics. First is the nature of sharing, including whether the service is truly shared, and expectations around payment or reciprocation, and questions of ownership. Second, reflecting the explosive growth in online services for shared travel, and the importance of user-centred design, is the technology of sharing, particularly from an end-user standpoint. This encompasses how the service is delivered, and the functions involved.

The nature of sharing

While shared travel is diverse in terms of the mode of transport used (bicycle, car, bus, and so on), there is equal diversity in the forms that the sharing of transport can take. The term ‘sharing economy’ has become common as an umbrella term to cover a number of schemes (travel and otherwise) that privilege access over ownership, yet it belies a range of modes of exchange. Sharing is a common, and perhaps fundamental, human behaviour of longstanding historical and anthropological interest (Mauss, 2000; Geisler, 2006; Harvey et al., 2017). There are different categories of sharing – sharing within groups (Mauss, 2000), ‘sharing in’ versus ‘sharing out’ (Belk, 2010), pseudo-sharing (Belk, 2014) and the rise of collaborative consumption (Botsman & Rogers, 2010). It is therefore useful to define different categories that could be considered as sharing, as this has a bearing on the appeal, relevance and design of a shared transport mode.

Pure sharing is closest to the description offered by Benkler (2004), where a resource, such as a spare seat in a car, is offered to another party purely for the benefit of the recipient. Strictly speaking, this is done without any formal expectation of remuneration, though some forms of non-travel online sharing, such as music sharing (Geisler, 2006), will track whether and how much a user contributes towards their use of a service (Belk, 2014). In practice, many non-transport pro-social sharing services work without the need for remuneration or reciprocity or can be embedded in the community rather than in specific relationships (Dickinson et al., 2016; Harvey

et al., 2018), despite the assumption that reciprocity is a prerequisite for community sharing (Harvey et al., 2018). However, over time, an ongoing sharing relationship may lead to an expectation of reciprocity or remuneration, and the need to negotiate in order to organise reciprocation, or awkwardness that arises when people are not able to reciprocate in a like-for-like form, have proved to be a barrier to lift sharing and often a reason for such arrangements being of limited duration (Lovejoy & Handy, 2011; Laurier et al., 2008).

A second form of sharing is **collaborative access** – where people work together, peer to peer, to access a resource that they either could not access individually, or where there are benefits derived from sharing. This collaborative access could be concurrent (e.g. clubbing together to hire a taxi; Sun et al., 2012), or asynchronous (e.g. two people jointly buying a two-way ticket, with one using the outward leg, and the other using the return). In such cases, supporting communication and coordination are vital, and this may again include the need to support arrangements for shared costs as much as for the logistics of the trip (Sun et al., 2012).

Finally there is **'pseudo-sharing'** (Belk, 2014). As the loosest definition of 'collaborative consumption', this includes monetised services that allow short-term access to a product or service (Belk, 2014), for example services such as bike hire, car hire and Uber-type services. Ultimately, these may draw on very different motivations from other forms of shared travel, such as being a cheap or readily available alternative, and therefore may need a different approach to marketing.

Questions of ownership

A second dimension to sharing is ownership, and the question of who ultimately owns the resource and rights to it. Sharing is sometimes talked about in terms of whether rights to the good are alienable or inalienable, or whether access to the good can be accessed exclusively (Ostrom, 2003; Lamberton & Rose, 2012). For the purpose of this report, we note two types:

- Personal or private ownership is where a private individual owns the transport resource, meaning that available capacity is offered by the owner as a service to another user (Botsman & Rogers, 2010). Alternatively, it could be where someone is giving access to the transport, but does not actually need to make the journey themselves (e.g., taking a child to school). Morency (2007) argues that this kind of family sharing may be generating rather than reducing trips, and may often involve a single occupancy vehicle trip one way (e.g. returning home after the school run). There may even be forms of sharing where the owner is not involved in the trip at all. An example of such a service is easyCar, where the owner can lease out their car on a short-term basis. If we include Uber as a form of sharing, it probably falls into this category.

- Third-party ownership is where the travel resource is provided by an organisation, for example Daimler providing the vehicle for Car2Go, or Zipcar. This has the advantage of having greater resources to support the pool of cars or bikes, and central coordination may be easier to manage.

Importantly, schemes that rely on a shared trip are more likely to require close matching between owner and user to make sure the owner is not overly inconvenienced by the trip. By contrast, schemes where the owner and other travellers do not share the same aim are more likely to require remuneration. This is related to the characteristic of altruism versus remuneration or payment. The sharing of the service may be purely altruistic, as in a volunteer driving older adults to a day centre. In practice, many sharers in informal relationships choose to reciprocate by giving lifts themselves on other days, or payment in kind (Lovejoy & Handy, 2011; Golightly et al., 2010). Finally, shared transport may be monetised (i.e., pseudo-sharing; see above and Belk, 2014). This may be a payment between individuals, which can either be informal (an informal agreement to pay petrol money) or, with technology, can be brokered. Brokered services, such as the ride-share service BlaBlaCar, offer to transfer money between passenger and driver at a fixed rate. In some cases, the broker will also take a fee, as in the case of Uber.

Discrete compared with ongoing use

The diversity within different models of sharing is also seen in the expectations relating to discrete versus ongoing use of services. This is important as it has implications for both the design and use of technology, for patterns of trust-building, and for concerns around remuneration or obligation (Lovejoy & Handy, 2011). Specifically, we differentiate between on-demand, planned single use, and ongoing use. An on-demand system calls up a transport service in or near real time, and each trip or block of usage is treated on a case-by-case basis. Car clubs and cycle-share schemes that allow drivers to request transport at very short notice, ride-share schemes that require little or no planning, and Uber services are all examples. One characteristic of on-demand services is that they typically rely on a mobile device with technology such as GPS. There is little time to establish trust, and therefore dynamic systems have been historically problematic for peer-to-peer arrangements, and are more viable when mediated through a reputable organisation (e.g. a third party such as Zipcar). In the future, other mechanisms for trust could be used, such as reputation scoring.

For planned single use, each sharing arrangement is treated on a case-by-case basis, but the arrangements for the trip are likely to require long-term planning. This may be because of the complexity of the sharing arrangements (e.g. for crowdfunded coach hire, or where the planned journey is a business trip or abroad), because specialist transport is required for specific mobility needs, or because the arrangements to secure trust are high (arranging trips for older adults or children). BlaBlaCar is an example of a planned single-use system. This can be desk- or web-based and leaves more time for nuancing the relationship, so giving users a greater sense of trust.

Ongoing use is where an arrangement covers multiple trips. For example, a workplace lift-share website may set up an ongoing relationship between two employees to share driving over a period of weeks or months. It is possible that a planned single-use instance (and even, possibly, an on-demand use) leads to an ongoing relationship. One of the challenges with ongoing, peer-to-peer relationships is the potential for users to ‘take their relationship offline’ and operate outside the system that originally matched them. While this can lead to a robust sharing

relationship, it is difficult to measure. It may also mean that the sharing capacity is no longer visible to other users of a service.

Rivalrous goods

A final dimension of our description of sharing is whether use of the resource is rivalrous or not (Lamberton & Rose, 2012; see also the notion of a common pool in Ostrom, 2003). A good can be non-rivalrous: the use of a shared good by one person does not prevent or limit access to the good for another person, so for example, looking at Wikipedia does not reduce access for other users. Alternatively, it can be rivalrous, where the use of a shared good by one person prevents or limits access for another user. In this case, borrowing a library book means that book is not available to another user for the period of its loan. If the use of a transport mode involves both personal ownership and exclusive use of a good by another (Ostrom, 2003), as in something like easyCar, there needs to be negotiation of property and access rights, which can act as a barrier to other forms of online sharing if not managed appropriately within the user interface (Harvey et al., 2014). Also, the availability of a shared good positively influences its appeal through the sharing system (Lamberton & Rose, 2012), and exclusivity of use can reduce that availability.

The role of technology

Technology is increasingly playing a role in enabling shared activity. From the web, through to secure mobile data and high-speed broadband services, and multifunction smart phones, new forms of technology both facilitate existing forms of sharing (Harvey et al., 2017), and enable new forms of sharing and exchange (Botsman & Rogers, 2010). Capabilities such as the use of near field communications (NFC) allow free-floating car-club schemes to operate without the need to hand over car keys to users (Kopp et al., 2013), and GPS or electronic payments increase the ease of short-term bike hire (Fishman, 2016).

Following a sociotechnical view of human factors, technology is therefore not just the passive enabler of sharing, but plays an active role in shaping the coordination of people and resources. If the technology does not adequately support sharing, it becomes a cost that acts as a barrier to sharing (Sharples et al., 2011), so reducing the perceived value of the proposition (Lamberton & Rose, 2012). Buliung et al. (2010) describe lift sharing as a sociotechnical system that stresses the importance of human capital as part of the system, and the design of technology to support users in their goals must match the sharing constraints and expectations of users. To that end, we define further concepts relevant to the role of technology in shared travel.

Platforms

The type of technological platform used to deliver a shared travel service can be completely informal, and also may take place by lower tech means such as email, for example within a workplace scheme (Golightly et al., 2010). Anecdotal evidence suggests that such low-tech arrangements should not be overlooked: they have value in terms of easily generated face-to-face contact when setting up a sharing community and in terms of e-communication to finesse planning arrangements and

generate trust (Brereton & Ghelewat, 2010). However, one implication for such services is that they are very difficult to monitor, and generate little data about their usage. As noted above in relation to ongoing peer-to-peer sharing relationships, lift-share matching services may generate matches that then persist unrecorded offline. Thus, while the service may appear to have relatively little patronage, it might prove to have been highly successful in actually facilitating shared travel. Measures of shared travel need to be sensitive to these 'hidden' trips and sharing relationships. Also, while social media adoption has plateaued, there is increasing adoption of private group messaging services such as WhatsApp (Ofcom, 2017). Such services are likely to provide a perfect ground for short-term offers and requests for informal shared travel, but are again likely to remain hidden from measurement.

Second, there are web-based services where a website is the primary means of access to the service. The service may be agnostic as to the exact platform used to access it (it may work on a mobile phone but be equally accessible through a desktop computer), and may not depend on the functional capabilities of individual mobile devices. In other words, it will not be conceptually dependent on being accessed 'on the go' even if that is possible. Finally, there are mobile-based services that either do depend on the functionality of a mobile device (such as a requirement for GPS) or are conceptually tied to the mobility afforded by using a mobile device on the go, anywhere, anytime. Some systems may be a hybrid, in that they require registration through a website but also require aspects of a mobile device such as NFC to secure access to a vehicle (Finkorn, 2012). Trends towards accessing all internet services through smartphones, particularly for newcomers to the internet (Ofcom, 2017) suggest it is reasonable to envisage a future convergence of all technology-enabled shared travel to the smartphone, and that services should be designed to exploit such functionality.

Within online systems there is again diversity. This can be defined as coordination systems, where the technology supports arranging the trip but not payment or remuneration. This may be completely coordinated, but also might be partial, and again this might be beneficial: there is evidence that users like to go 'offline' from the core coordination platform to nuance trip details, and also to gain greater trust (Brereton & Ghelewat, 2010). As well as coordination systems, there are full brokerage systems, where all aspects of the trip, including monetisation, are covered in the system design. Examples of this include free-floating car-club schemes, where users pay an upfront charge for using the car over a day or a month.

Table 3 assembles a number of shared travel modes, and presents them in terms of the characteristics of sharing and the enabling technology. The categories shown in Table 3 demonstrate the variability of different forms of shared travel service, and how key aspects other than mode can be assessed. Also, it can highlight for, say, a local authority, where different schemes might be complimentary or competing. This is important as, on one hand, too much similarity between schemes in the same area can lead to confusion and rejection (Morency, 2007; Buliung et al., 2009), while equally, schemes that look as if they compete in terms of mode, may on deeper consideration address subtly different markets in terms of technology or sharing model.

Effects of rivalrous modes

As can be seen from Table 3, almost all shared modes of travel are rivalrous, that is to say, use of the transport capacity by one traveller or group of travellers subtracts the availability of the resource for other travellers (exceptions include shared cycling and walking (Kingham & Ussher, 2005; Mcilvenny, 2015). Any shared good is less appealing when it is known that there may be competition for its use (Lamberton & Rose, 2012), and therefore the availability of the shared system must be such that users have confidence in its availability, and the perceived risk of scarcity is minimised. The drawbacks of rivalrous modes of travel are exacerbated when there is the promise that the transport will be available on demand rather than requiring planning, yet this on-demand nature is vital if shared transport is to compete with the convenience of the private SOV. For ownership-based, peer-to-peer schemes (such as lift-share schemes), the challenge is to ensure sufficient capacity that is geographically near enough to an intended traveller to support the journey. In fact, this is extremely difficult to achieve (Teal, 1987) unless travellers have very similar patterns. For this reason, organisational lift-share schemes have the double benefit of a shared start and end point, as well as a level of trust that comes from belonging to the same organisation.

An alternative is for capacity to be provided by third parties. For third-party managed schemes, such as the shared bus service Kutsuplus in Helsinki, or dockless bike schemes such as ofo, the answer is to flood the market with capacity to the point where the service is no longer economically viable (Citiscope, 2019; Haas, 2017). It is important to note that in the Lamberton and Rose studies (2012), this perceived risk of scarcity applied not only to the transport, but also to the supporting infrastructure (in this case, cycle lock-up points). For car-club schemes, increasing the number of cars does not necessarily increase the number of users, but it does increase number of uses (Habib et al., 2012).

Implications

Shared travel has diversity not only in travel mode, but in types of sharing, and in types of functionality. Policy measures at a local, regional and national level should be as cognisant of supporting a range of forms of sharing, and of the risks of overlap in terms of sharing type and technology, as they are of the mode.

Specifically, sharing forms should fit the differing needs and expectations of a given demographic segment. For example, reciprocity in a shared travel network cannot be assumed, and may be seen as a cost and so a barrier to usage. This is most apparent in ongoing sharing arrangements, and careful scheme and technology design should be applied to lower that barrier. For single (on-demand or planned use), discrete payments are easier to negotiate. Collaborative access will be more dependent on communication and collaboration. Reciprocity may be relatively scarce in sharing communities, and the means to support remuneration, where required, may need to be considered as part of the technology's design.

For technology type, even online services may lead to offline and low-tech arrangements. Therefore, the success of a scheme should not only be measured by

interactions with online sharing systems. This is particularly relevant to ongoing sharing relationships.

Almost all shared travel is exclusive, and exclusivity reduces perceived utility. This has to be overcome by high-quality matching and suitable ‘critical mass’ in peer-to-peer systems, or by third-party providers being able to deliver that capacity. Strategies to support peer-to-peer sharing should be aimed at generating that critical mass, which includes not only the provision of the service, but careful marketing and promotion that include, as discussed later, active personal promotion and human capital in supporting the scheme.

Table 3: Modes with consideration of sharing type and technology

	Sharing	**Ownership**	**Payment**	**Rivalrous**	**Technology platform**	**Functional range**	**Usage pattern**
Personal use of car	Personal use	Private	None	No	None	N/A	N/A
Giving a lift to a relative	Pure sharing	Does not share in outcome	Altruistic or reciprocal	Yes	None	N/A	N/A
Ride share	Collaborative access	Shares in outcome	Brokered	Yes	Web	Brokered	Planned or ongoing
Cycle hire	Pseudo-sharing	Third party	Complete	Yes	Web	Full	On demand
Taxi share organised by marshal at airport	Collaborative access	Third party	Brokered	Yes	None	N/A	N/A
easyCar	Personal use	Private ownership	Complete	Yes	Web	Brokered	Planned

5. The decisions of sharing

Not only does decision-making pertain to how a given trip might relate to the individual's requirements (time savings, cost savings, environmental impact etc.), it is also influenced by human–computer interaction in the design of sharing services, and how these need to exhibit general usability, and specifically to represent the key decision-making criteria for travellers, such as encouraging trust in the travel provider (Brereton & Ghelewat, 2010; Harvey et al., 2017). In this regard, there are strong 'behavioural entanglements' between the technology, needs and practices of mobility, and the potential modes of sharing (Schwanen et al., 2011).

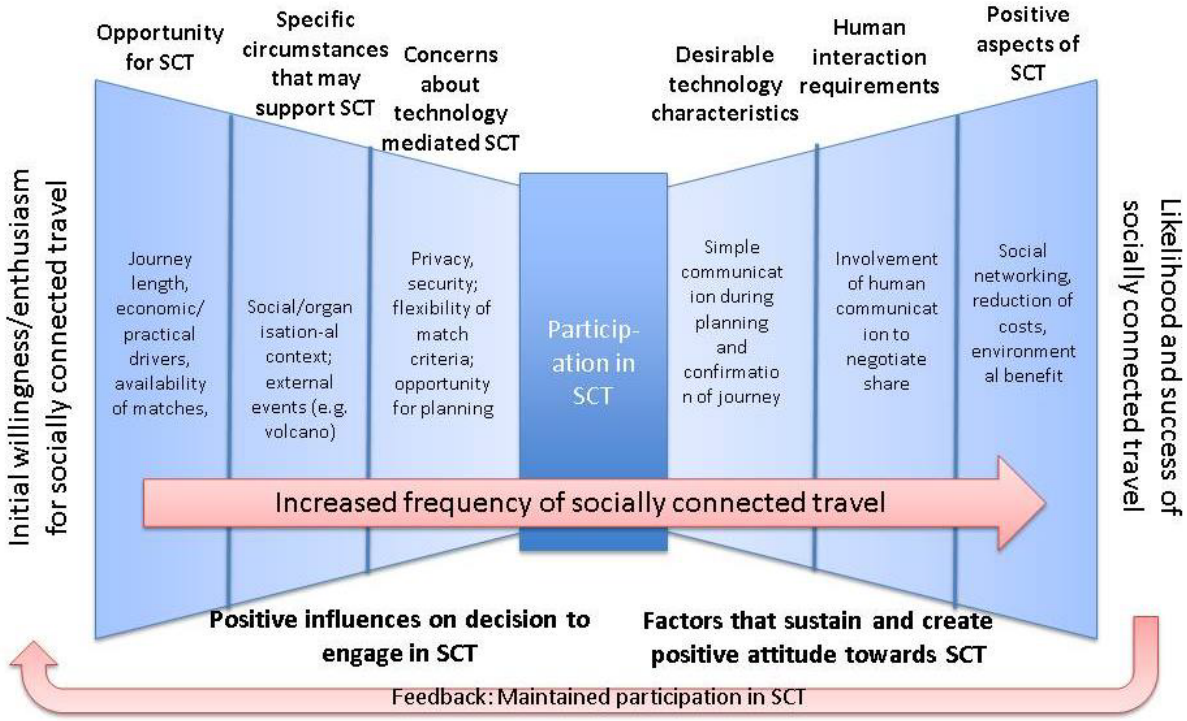
At the outset, it is important to reiterate that decision-making on travel does not adhere to conventional or instrumental views of decision-making. Travel is highly influenced by habit (Gardner, 2009), which can have a significant moderating effect on planned choices or the influence of social norms, as usually expressed in Theory of Planned Behaviour (Ajzen, 1991). This is likely to be seen in sharing as a poor rate of conversion from joining a scheme to actually using it (Buliung et al., 2009). For example, in a diary study of propensity to lift share, while participants expressed amenability to sharing lifts, in practice out of the 400 journeys recorded, only one journey was identified where a driver was prepared to travel as a passenger in a shared journey (Cranwell et al., 2012).

Similarly, work on travel decision-making generally indicates that traveller knowledge is not neutral to travel decisions, and that regular travellers can be viewed as experts (Gustafson, 2012; Kurup et al., 2017). The implication of expert knowledge and decision-making is that travellers arrive rapidly at their decisions. They are more likely to be influenced by their recognition of expected (and unexpected) elements of their journey than actively searching for information (Klein, 2008). Hence they arrive rapidly at a planned course of action that needs substantial evidence to alter, rather than (as, potentially, a novice might) taking time to reach a course of action logically (Shanteau, 1988). Both habit, and its counterpart, knowledge, mean that travel choices and habits are extremely resistant to change and should not be viewed as purely instrumental decisions. Others stress, however, that habit is not a static external factor that acts as a constraint on decisions (Shove, 2010; Middleton, 2011). They argue it is an active part of the practice of travel reflecting (i) the constraints and opportunities of the context that the traveller(s) are embedded within, and (ii) something that is enacted through the practice (i.e. the execution) of travel rather than being an 'input' before travel choices are made. Habit is a means to cope with complexity (of choice, of information) and therefore can be seen, not as constraint, but empowering. This is important because it implies that changing habit is not altering a set of presuppositions or learned behaviours regarding a travel practice, but instead adapting the travel context, and making clear the travel opportunities for change (see Shove (2010); Middleton, (2011) and Schwanen et al. (2011)) in order to engage with habit across the journey.

How people arrive at their decisions and sharing behaviour, and to do so repeatedly should therefore be viewed as a longitudinal process that both involves layers of influencing factors before the initial decision to share, and then will develop (or decay) over time as a result of repeated usage of a shared transport experience

(Sharples et al., 2011). As Bissell (2014) proposes, 'the past is constantly transforming the present'. This varies between mode, with negative experiences of public transport being particularly memorable and influential on travel experience (Friman & Gärling, 2001), in comparison with personal travel. It is an interesting research and practical question as to whether different shared-mode experiences are seen more as discrete events (as with public transport) or more a continuous experience (as with the private car). Overall, we argue that the sharing of systems needs to be considered both as a sociotechnical process, and a dynamic, ongoing process that may evolve throughout an individual's life, reflecting changes in circumstance, activity and geography, and intersecting with established habits and varying incentives. We present this model in Figure 4 as a model of socially connected travel (SCT).

Figure 4: SCT: a model of sharing behaviour and adoption over time



Opportunities for socially connected travel

At the outset, there is an initial interest or necessity for shared travel. Influences on this willingness or enthusiasm may be attitudes towards the environment or financial circumstances (Costain et al., 2011; Kopp et al., 2015), as well as preferences for social interaction during travel (Lovejoy & Handy, 2011). Different segments will have different levels of amenability to different forms of shared travel mode. Typically, less affluent users use sharing as a cost-saving measure, and in some cases it may be an indispensable means to access health or employment opportunities for parts of the community with limited access to transport, even in urban environments (Palacin et al., 2016). The second group is likely to be wealthy, employed, living in the urban environment and using shared travel as a means of reducing or eliminating the need for car ownership. Interestingly, use of sharing for this group is intertwined with public transport use. They are 'mobility optimisers' (Kopp et al., 2015), or

'supersharers' (APTA, 2016). The importance of sustainability as a motivating factor varies depending on the mode of travel. Many users of shared cycle schemes are already aware of the positive benefits of active travel, along with users of organisational lift-share schemes (Golightly et al., 2010) and an environmental orientation is also linked to the adoption of lift sharing (Delhomme & Gheorghiu, 2016). However, explicit representation of CO_2 emissions and other environmental benefits in travel apps and tools has not been found to be a significant motivating factor (Chatterton, 2009), and a study in Denmark found that sustainability is a relatively low motivator to share in comparison with costs, and was less motivating as a means of encouraging lift sharing (Nielsen et al., 2015).

Journey distance has been found to affect the propensity to share – people with longer regular journeys are more likely to share, because of the reduced comparative impact of the extra time required for diversions to accommodate picking up and dropping off passengers (Tsao & Lin, 1999; Jacobson & King, 2009). Also, there are questions about how many people have the correct financial drivers and density of potential matches around them to create the 'critical mass' necessary to make lift sharing a viable alternative (Teal, 1987; Tsao & Lin, 1999).

In a qualitative study of lift sharing in Denmark (Nielsen et al., 2015), negative perceptions reported by respondents include lack of availability and difficulty acquiring lifts, perceptions of lift sharing as unsafe or insecure, and expectations of social awkwardness, among others. Positive perceptions reported include cost savings compared with public and private transport, greater flexibility of travel times, and the ability to socialise with vehicle occupants. Indeed, this emphasises not just the emotional but experiential aspect of travel and therefore of sharing, in that some forms of shared travel can be an emotional shared experience (shared walking or cycling, or taking time to travel with friends). In other contexts, the shared experience is a negative one, particularly when considering both the physical and social proximity to strangers. This can be both an impediment to shared travel (including on public transport such as trains; Cox et al., 2006), and may be more acute for certain cultural groups (Remland et al., 1995).

Circumstances supporting socially connected travel

The social context plays a key role in supporting sharing relationships. This might be specific company incentives to encourage shared travel (Golightly et al., 2010) or one-off external factors, for example, that seen in the aftermath of the volcanic eruption in Iceland that affected flights in 2010, or in response to other transport disruption (Kelestyn et al., 2017).

For company-based lift-share schemes, work patterns, especially shiftwork and flexitime, may interfere with acceptance of lift-sharing (Buliung et al., 2010) or point to a preference for dynamic lift-sharing technology (Dailey et al., 2001). Other barriers are the social awkwardness of sharing personal space, arranging remuneration or reciprocity of sharing (Laurier et al., 2008), and concerns about personal safety and trust (Chaube et al., 2010). These latter concerns cover both the perceived risk of harm when encountering a stranger and also the perceived risk due to other people's driving style (Chan & Shaheen, 2012; Nielsen et al., 2015), though the thresholds for this may be reduced in certain settings, such as during holidays

where an informal, short-term community exists (Dickinson et al., 2016). Organisational schemes have the benefit of a shared community, and users prefer the taxi-share scheme concept if they are going to or from an anonymous location (e.g. an airport; Sun et al., 2012). As noted earlier, the nature of the social network shapes expectations around remuneration and reciprocity in ongoing relationships. We highlight again that community (Lovejoy & Handy, 2011) or other non-work groups can be used as a basis of sharing organisations, and that ad hoc groups (for example for taxi sharing) can work in certain situations where there is both oversight and anonymity (Sun et al., 2012). However, we note few successes to date, despite early interest to leverage people's existing online social networks (Chaube et al., 2010). Anecdotal evidence suggests that people have many reasons for following people on Twitter or Facebook, but this does not necessarily mean they would make good sharing partners (Golightly et al., 2010).

Returning to the characteristics of sharing, we stress that organisational factors are of greater relevance in shared modes that require peer-to-peer collaboration, or where people actively share the travel, due to the increased importance of interpersonal trust, comfort with the other person and so on. It is less relevant when a third party provides a monetised service. The importance of social factors varies depending on the type of service. For example, it may have little relevance to a city-based cycle-hire scheme, where there is little or no need for interpersonal contact.

One vital factor is promotion. An assumption by organisations that technology on its own is enough to encourage lift-sharing schemes has led to a reduction in the number of people who have previously supported and publicised lift-sharing initiatives (Buliung et al., 2010). This has decreased awareness of such schemes (Chaube et al., 2010), and so ongoing support, also seen in the adoption of non-technology walking bus schemes (Kingham & Ussher, 2005). Ultimately, schemes, particularly those dependent on peer-to-peer networks, rely on human capital to make sure that connections are made, and people are informed of how the technology works, and who is available to share travel.

Concerns around technology and socially connected travel

In their theory of sharing behaviour, Lamberton and Rose (2012) propose a number of costs associated with the organisation of shared travel. While this can include the actual cost (in time, money and effort) of the trip itself, it also includes the costs of technology, in terms of how the technology can ease or hinder the experience of sharing, and also search costs, in terms of how the user finds both the shared mode and the specific trip provider they require. Technology, and specifically the human–computer interaction characteristics of online shared travel services, have a bearing on both technology and search costs.

A review of early on-demand lift-sharing technologies (Levofsky & Greenberg, 2001) found the basic usability of a number of schemes was a major barrier to their adoption, and an evaluation of a live lift-share deployment (Sharples et al., 2011) found significant issues with the presentation of maps and routes, and difficulties for users in understanding the privacy model provided by the technology. Subsequent proposals for lift-sharing technology have highlighted important considerations such as:

- the structure required to submit matching requests (Dailey et al., 1999; Wash et al., 2005)

- the availability of chat-like functionality (Brereton & Ghelewat, 2010) to finesse trips and build trust

- the use of multiple platforms (Wash et al., 2005; Morse et al., 2007)

The design of the technology needs to accurately reflect both the availability of travel modes, and the form of sharing, for example whether it is fully brokered. Increasingly, the technology must be adapted to the capabilities of the smartphone. Also, clarity can be undermined when there is more than one competing service within a given area. Morency (2007) found this to be the case with lift-share schemes, and similar concerns are now being raised anecdotally regarding the growing number of docked and dockless bike-share schemes.

Factors that sustain sharing

At the heart of the SCT model is the interaction with any service to arrange shared travel. One key consideration is that travel sharing is a process that develops over time, rather being a series of single instances of decision-making. After the decision to share has been made, a number of steps need to play out. First, the potential to share does not mean that sharing will actually occur (Cranwell et al., 2012) – the evidence suggests that only a minority of registered users of online lift-share schemes actually engage in lift sharing (23% in the case of Biliung et al., 2009).

Thus, for planed shared travel, or for the first experience of an ongoing relationship, the initial set-up has to transform into an actual positive travel experience. Even with on-demand services, a user must be made aware that the capacity is available to enable their trip, including that there will be a free bike stand at their destination, that their car will be there when they arrive, etc. Mobile devices and real-time data can do much to ease this process. Once the shared travel has taken place, there are still influences on future intention to use. It is at this point, once a person has shared a journey, that the positive aspects of SCT, such as social networking, reduction of travel costs and environmental benefits, have an impact. The elements in Figure 4 on the right-hand side of the model can be considered elements that encourage the ‘habit’ of SCT to be formed.

The importance of the factors on the right-hand side of Figure 4 and post-sharing factors cannot be overlooked, and is an area needing further research, since one of the major downsides of shared travel schemes is that they often struggle to maintain an active user base (Buliung et al., 2010; Costain et al., 2011; Citiscope, 2016). This is particularly a problem for peer-to-peer systems, since membership needs to be maintained in order to offer a significant pool of resources for matching. Peer-to-peer schemes in particular must be dynamic and incremental, although one of the factors inhibiting this is that early adopters using new forms of shared travel are more likely to be risk taking and exploratory and therefore less likely to show loyal or habitual behaviour patterns (YouGov, 2016). This might explain why some schemes have failed to maintain membership levels (Costain et al., 2011).

Implications

Shared travel develops over time, and most emerging services have at their heart a human–computer interaction which is used to negotiate the form of sharing. Factors build over time to lead to the execution of the travel, but also shape perceptions after the event.

The influence of post-sharing factors is vital, given that the use of schemes can decline over time, yet is often overlooked. Services (and policies) must treat the sharing experience across the whole range of stages of sharing. For example, financial and marketing support can follow the sharing experience, and promotion (including user advocacy) should be an assessed, ongoing part of any scheme's strategy. Policy, marketing and support must reflect that shared services need ongoing support, not simply initial investment. This may be more apparent in peer-to-peer services, where experience of the transport offer needs to develop alongside the personal relationships that sustain it.

Cannibalisation or confusion between multiple schemes is also a risk to sustainability, and consequently schemes and services must be assessed as a suite across a given area to reduce the risks of overlap.

Finally, for peer-to-peer and collaborative schemes, the social and organisational context is paramount. Even loose associations (such as online social networks, or different organisations in the same business park or building) rarely result in effective sharing networks, and therefore peer-to-peer and collaborative schemes, particularly for ongoing relationships, are still best served by targeting existing organisational settings such as workplaces, social clubs and so on.

Enabling factors

The SCT model must take place in a broader context of enablers. This is particularly relevant to setting up positive conditions to generate enthusiasm and viability for shared travel services. We note the key enablers, highlighted from the literature, below.

Public transit

Foremost is the role of public transit. Shared modes are likely to be used by those who already have travel flexibility, live where public transit is easily available, and seek to optimise their journeys on a case-by-case basis (Kopp et al., 2015; APTA, 2016). These users are also likely to be more environmentally aware (Costain et al., 2011). Public transit in particular is vital to this and typically forms a major part of most sharers' travel planning (Kopp describes it as 'the backbone' of shared travel services). As noted previously, it is not only that public transit will be used alongside shared travel as a transit option: it is likely that shared travel (particularly bikes in urban environments) will be used in conjunction with public transit in a single trip. Therefore, support for public transit as complementary, rather than an alternative to shared travel is a vital consideration, and both public transit authorities and shared travel supporters must work collaboratively to achieve a seamless service (this has implications for Mobility as a Service, discussed later). One example of this is

Copenhagen, where Arriva have teamed with BMW to use short-term car hire in combination with public transit (Passenger Transport, 2015).

Infrastructure

Infrastructure is a key element of sharing, and policies need to reflect the availability of parking for cycles (Sun et al., 2017) and cars (Shaheen et al., 2009; Finkorn, 2012). This is crucial on two fronts: first, fewer parking and lock-up locations will mean that there is less likely to be a space to park. If a resource is perceived to be rivalrous, it will be less appealing (Lamberton & Rose, 2012). Second, the further a person has to travel to access a resource, because they are distributed more sparsely, the more the perceived cost in terms of effort and time will rise and, again, it is less likely to be selected in preference to other, easier modes. As electrification takes a role in lowering the cost of shared vehicles, this will also need to be taken into account for charging stations. The positioning of infrastructure, and policies to support that positioning, should also take into account enabling factors such as high residential density, employment density, access to public transit services and also the management of perceptions of crime (Sun et al., 2017).

We note that third-party schemes, such as car clubs, are increasingly driven by needs of the shareholder rather than policy (Firnkorn, 2012; Kitchin, 2014). The costs of operating such systems need to be managed as a partnership between regulators and the private sector. For example, insurance is a major operational cost and barrier to the adoption of third-party car clubs, accounting for the closure of several schemes in the early days of car clubs (Shaheen et al., 2009). The recent issues with Uber securing appropriate licenses to operate in London (TfL, 2017) potentially mark a change in how cities wish to regulate third parties that provide shared transport.

Sharing has a particular role in the transport planning process, therefore. To date, sharing is typically best suited to short (cycling, first and last mile, commute) and medium (commuting in from the suburbs for lift share) journeys. While sharing can be encouraged from central government, practical planning should take place at a local and possibly regional level. This planning should cover not only the support of the mode, but also associated infrastructure, and may include regulation of newer, emergent services (as with Uber in London). Even in deregulated environments, planning may involve ensuring a complete set of services, where services complement rather than cannibalise. Importantly, and even for these deregulated contexts, local and regional planning can support technical integration while still leaving an open market. For example, the recent Transport for North strategy (TfN, 2018) does not directly cover sharing. However, plans to set up an integrated back office for consistent payment mechanisms across the North should be future-proofed so that shared transport services will also be able to draw on the same mechanism, thus giving users a consistent experience. We also note a challenge for transport planners in being able to capture and model shared trips in the future. While bike share typically generates data, other forms generate less reliable data (see Table 1). Attention should be paid as to how future technologies could accurately capture lift share[4].

[4] For example, see TfL's Project EDMOND, which uses mobile data to estimate demand measures.

The importance of planning measures in respect of lift sharing has long been understood, particularly in the US, which has long implemented a programme of high occupancy vehicle (HOV) lanes. A number of schemes have been introduced in the UK with modest success (DfT, 2006) and some increases in sharing, though this has often been coupled with an increase in use of public transit. For lift sharing, it is still the case that the importance of the organisational scheme means decisions around specific measures, such as rewards for sharing, or priority use of parking spaces, are also useful, albeit incomplete, incentives (Golightly et al., 2011). This highlights that maybe the most important role is the organisational travel manager or travel planner, who can both implement the right measures for the specific organisational context, and promote measures internally with staff, even when technology matching is available (Buliung et al., 2010).

We summarise the barriers and enablers to shared transport in Table 4.

Table 4. Key enablers and barriers for shared transport

Enablers	Barriers
Integration with public transportation	Lack of human capital to support services
Infrastructure (cycling docking; cycle lanes; car-club parking; safe stops for community bus services)	Confusing and competing transport marketplace
Technology infrastructure (wi-fi; 3/4/5G); integration with payment platforms	Lack of understanding of shared travel as an ongoing and evolving process
Regulatory partnerships with third-party providers	Low-cost effectiveness (or even loss) of services
Local policy management to meet specific needs in any given locale	Difficulties in measuring usage (e.g. services are more popular than they look)
User-centred design for sharing technology	Overcoming the appeal and logistical benefits of the private car
	Framing benefits around sustainability or environmental aims

Existing practices

One way to assess success (and barriers to success) is to understand the relative performance of different recent case studies. Examples of success stories include the London cycle-share scheme, which has seen year-on-year growth. Keys to success have been continued infrastructure investment, close linkage with public transit, appropriate fit between the mode offered and the type of travel required and the user base (affluent men wishing to travel short distances). Outside the UK, car-

club schemes have been effective, particularly in Germany. While the usual reasons of urbanisation and decreasing car ownership are cited, the fact that such schemes are now supported (both financially and in terms of providing cars) by major German car manufacturers has been a key to success. Anecdotally, the ability to provide higher prestige cars (BMWs, Minis) for car schemes has proved a motivating factor for demographics who might otherwise be reluctant to share. A final example of a successful scheme is the partnering of BMW with Arriva in Denmark (Passenger Transport, 2015). Again, a success factor here is the ability to provide high-quality cars at scale, plus integration with public transport. Historically, lift share has proved popular in some specific areas such as the Bay Bridge area of San Francisco (known as 'slugging'), where there is a culture and network that together support informal sharing, prompted by high tolls on bridges (Ma & Wolfson, 2013).

However, an overwhelming impression going through the literature is that, bike sharing aside, examples of formal schemes using modern technology with hard evidence for success are thin on the ground. This is in part due to relatively few successful schemes, and possibly because of the role of third parties in bringing in increasing commercial sensitivity.

Searching for examples of shared travel services reveals many failures. In particular, the formal design of community bus services operated commercially by third parties seems to be particularly problematic. Bridj, Split, Kutsuplus and Chariot are all examples that appear to have failed, despite in some cases having support from major companies such as VW and Toyota. It is unclear why most of these have failed, though the simple logistical difficulty in meeting demand in terms of a regular service makes it difficult for the service to be cost effective. It is noticeable that more successful services in the UK tend to be volunteer operated, charitable or community-based.

Another example of less successful services are those that have tried to deliver real-time lift sharing. Despite promise and much research interest in the area, there are few, if any, large-scale commercial services. One example is Carma, previously Avego, which despite being around for over 10 years is yet to see any large-scale deployment outside a few pilot schemes. The lack of lift-sharing infrastructure, lack of critical mass (a problem the US has attempted to resolve by deploying close to HOV lanes) and the complexity of registration to ensure safety, trust and micropayments, are all barriers to use. Finally, despite the potential for cycle sharing, not all schemes have been successful, with issues and false starts to schemes outside London, particularly because such areas do not have high enough density and ridership to ensure that there is still a sufficient supply of bikes once some have been lost, stolen, damaged or otherwise put out of availability. Despite having one of the highest uses of cycles in the US, Seattle recently closed its cycle-share scheme with issues around low ridership, delayed expansion and lack of political motivation (Citylab, 2017).

Implications

Public transport is inextricably linked to shared travel. Shared travel can supplement, but not replace, public transit, but making the links (logistically, as well as

conceptually) between shared travel modes and public transit in the mind of the public can do much to confirm its appeal. This includes:

- policy around positioning of physical infrastructure;
- use of ICT to support greater interconnectivity;
- MaaS, such as a common charging infrastructure for shared bikes; and
- car share within a larger transport system (see below).

Packages to support shared travel must take into account infrastructure cost and availability. Going back to both sharing and technology characteristics, and their impact on user decision-making, perceived lack of infrastructure will make the service look more exclusive and rivalrous, decreasing its appeal, and therefore the clear availability of associated infrastructure (including the costs of accessing it, e.g. positioning and availability of bike docks) must be designed into the technology, and costed into operations.

Finally, we note that the contribution and responsibility for shared travel are increasingly moving to the needs of shareholder, not just transport policy. There needs to be awareness at board level of the factors discussed in this report to ensure that such schemes reflect the need of the user. This, for example, could be advocated through embedding user-centred design processes (e.g. ISO 9241-210) (Gargiulo et al., 2011), as well as being able to state the clear return on investment for strong user-centred design (Usability Matters, 2017).

6. The future of sharing

Having reviewed a set of considerations for shared travel, we now reflect on evolving technologies and wider social trends. The section will explore how these predicted developments between now and 2040 will interact with the psychology of sharing.

Mobility as a Service

Mobility as a Service (MaaS) can be defined as ‘the integration of various forms of transport services into a single mobility service accessible on demand’ (MAAS Alliance, 2017). The wider vision is that through the interoperability of transport data (services, route, pricing, availability) and ticketing and payment systems, it should be possible for a traveller to plan and pay for a journey optimised to their requirements that might encompass a range of transport modes, including public and shared transport, using a single point of access. Creating truly effective MaaS solutions is a considerable challenge since it requires the resolution of technical, regulatory and business-model issues across a full range of transport modes and services (Transport Systems Catapult, 2016; MAAS Alliance, 2017).

Potential and considerations

The development of MaaS offers significant potential for the growth and sustainability of shared transport modes, particularly because many of these are already based around online, digital methods, albeit often operating through proprietary apps. This may, however, contribute to generating the critical mass needed to sustain shared modes simply by making them more easily discoverable. Additionally, given that shared modes may not be a full replacement for all transport needs (and indeed arguably work best when combined with a public transport backbone), seamless integration into an end-to-end journey through MaaS will optimise the ease with which they can be accessed and used and possibly act to 'normalise' shared transport.

At the currently formative stage of MaaS, it is important that shared transport is part of the ecosystem and considered alongside more established public transport modes. This may require addressing regulatory barriers and the reconciliation of public and private offerings. In order to ensure the presence of shared travel within MaaS, data standards and application programming interfaces (APIs)[5] will need to be capable of handling and representing as fully as possible the diverse range of sharing practices discussed above to allow for innovation. The consequences of individuals facing exclusion from MaaS should also be considered, however, and would add impetus to efforts to close existing 'digital divides' in terms of access to technology and the internet for economic, attitudinal or educational reasons. Further, given that trust, privacy and safety are significant barriers to peer-to-peer transport sharing (Chan & Shaheen, 2012; Nielsen et al., 2017), this should at least in part be addressed through the provision of appropriate information, and thought given to interface features that best support shared modes (e.g. supporting the negotiation and nuancing of shared travel). Over a longer period, the data collected from MaaS (i.e., planned multi-stage journeys) can itself be used to further develop shared transport by identifying innovative market opportunities and gaps. When successfully presented back to travellers, this can also be used to generate and sustain involvement and the use of shared travel schemes. Indeed, socially connected MaaS may even facilitate this among communities of travellers themselves. This will require a degree of data reciprocity between all stakeholders using these platforms from large providers, likely small shared transport scheme operators and possibly through to users themselves. This principle may have to be fought for, as asymmetric access to the data could generate market advantage to an exclusive set of holders (Spinney & Lin, 2018).

However, while MaaS might work well for third-party services, it is less clear how it will support peer-to-peer informal sharing, which forms a significant part of the sharing landscape. There also needs to be scope in a MaaS market operated by major organisations for the growth of more 'grass-roots' sharing initiatives whether technologically enabled or not (see www.hstl.org.uk/contactus.php).

[5] An application programming interface (API) is a set of defined methods of communication between different software components. It is used so that different applications can communicate with each other.

Automation, electrification and the connected car

We are currently seeing significant technical developments in vehicle technology that are moving away from the standard, human-driven internal combustion engine to an electrified and at least partially automated vehicle that can increasingly both collect data about itself and its environment, and communicate with other vehicles and perhaps even infrastructure itself (DfT, 2015; Transport Systems Catapult, 2017; UK Centre for Connected and Autonomous Vehicles, 2017a). Automation may range from aids to drivers (e.g., automatic parking and collision avoidance) through to fully automated driving where the driver intervenes only by exception and the car could (in principle) operate autonomously. Current examples of automation and electrification include cars and trucks produced by the Tesla company, but most manufacturers now have advanced R&D programmes in these areas. Electrification is also now strategic goal of many governments by 2040, including the UK government, as part of environmental and air-quality policy.

Potential and considerations

Automation, electrification and connection offer a range of potential benefits in the area of car- and lift sharing. Electrification reduces the environmental footprint of transportation in general, and sharing journeys will still further reduce this on a per-mile basis. Connection would serve to support ever-more convenient and timely services that leverage increased intelligence about the availability of both riders and vehicles (this could even become partially predictive based on big data analysis, perhaps in conjunction with MaaS systems). Both automation and connection may also serve to reduce some barriers to lift sharing in relation to perceived risks. Allowing sharers and others to, for example, track the vehicle in real time, and offer information about the maintenance state of the vehicle and objective records of how it has been driven may improve confidence in the safety and quality of the service on offer. Automation, by improving safety and offering perhaps a more standardised pattern of driving (whether autonomous or with some human input) may also reduce concerns about the quality and safety of the ride ahead. Further into the future, autonomous cars may offer the potential for driverless taxi and lift-share services or for shared ownership, pool schemes or pay-as-you-go schemes where the vehicle ‘delivers itself’ to the door when required. Given that the average car spends much of its time parked, this would lead to far better exploitation of the asset. However, the acceptance and acceptability of automated cars remains open to question and in itself is subject to many of the sociotechnical challenges discussed more widely in the present paper (see Merat, Madigan & Nordhoff, 2017, for a comprehensive review).

In the short term, there are still uncertainties about whether the infrastructure will exist to support electric cars and vehicles with sufficient charging points over sufficient geographic spread relative to the range of the vehicles. In the case of automation and autonomy, large questions exist about both the legal and legislative support for their use and how things such as insurance and the understanding of liability for accidents will unfold; autonomy and connection may also require the extension of smart infrastructure and the availability of resilient data-networking services (Centre for Connected and Autonomous Vehicles, 2016, 2017b). In the longer term, if the vision of a ‘third transport revolution’ is indeed realised, where ‘car

ownership goes the way of the DVD' (Zimmer, 2016), it will raise a range of disruptive questions about the wide range of business and taxation models based on private vehicle ownership, not to mention the design of our urban and suburban spaces. Some thought will also need to be given to models of competition and market access.

Wider social changes

As identified earlier, the perceived acceptability of sharing and the decision to share are in large part formed by the needs of individuals in relation to the services available. Wider social changes, which can be quite complex in their interactions, are therefore relevant if they change people's circumstances in a way that changes their transport requirements. It has been noted recently that we have seen a steady decline in the numbers holding driving licences since a peak was reached in the 1992–94 period, and a decline in trips taken by car and indeed, in general, with public transport and walking seeing only a modest compensatory uptake. Chatterjee et al. (2018) point out that this is likely a result of a complex intersection of changes in lifestyle, sociological and economic factors that generally cluster around changes to work (a decline in stable full-time employment), a decrease in disposable income against rising costs of motoring, and a more general delay in reaching traditional markers of adulthood (moving out of the parental home, leaving training, marriage, children, independent living). Another significant trend is the growth of our cities (although this may not be equally distributed across the country; see ONS, 2016). As many existing travel schemes tend to focus on, and be successful within, a city environment, this has clear relevance to the growth of such schemes. A further, potentially linked, demographic change of interest concerns the normalisation of the use of mobile technology and access to the sharing economy. One major, recurring barrier to sharing remains attitudinal – individuals used to private travel may simply not want to share what was previously typically privately owned. It is possible that as the 'sharing economy' grows, individuals become more accepting of, and have greater confidence in, the proposition that it might be better to pay for access to goods and services rather than ownership. How far into the future these changes persist (as the cohort ages) remains to be seen, and it may be reinforced or further modified by wider changes in British society and the economy.

Against this backdrop of changing patterns of life (and consequently transport use) among younger individuals, another major trend in the UK is the demographic change leading to an older population that will increase the need for mobility options that serve their needs (Government Office for Science, 2016). In addition to living longer, it is also considered that people will work longer, thus creating an overlap between the rising age of this group and the requirement to travel to work. This cohort is likely to have a more established investment in car use that leads to different embedded attitudes. Further changes in patterns of work that affect workers across society may also pertain to older travellers, particularly with the growth of 'portfolio careers', flexible working and the so-called gig economy (UK Commission for Employment and Skills, 2014). This may lead to great variety in when and where people need to travel in ways that may be hard to predict as these new forms of work evolve.

Potential and considerations

The likely implication is primarily the emergence of new demands to be addressed by the transport system, which shared travel could be part of meeting. Particularly for older workers, shared travel may be a vital component in enabling their continued mobility and, if required, engagement in the world of work. In the short term, one barrier to securing this may be lack of comfort with and acceptance of digital technology. However, in the longer term, this should be less of a barrier as the next generation of older people are today's existing mobile phone and internet users. Further, while automated vehicles may offer what at first blush appears to be a clear solution to the problems of mobility for the elderly, on current research, as respondents age, their stated intention to use automated transport declines rather than increases (Merat et al., 2017). Urbanisation also lends itself to the consideration of shared transport as it both creates a distinctive set of travel needs, and poses a challenge to already stretched urban transit networks, but also provides a major enabling feature of shared transport insofar as the sheer density of people would help form the critical mass required for sharing schemes (Kopp et al., 2015). However, this may be balanced against declining driving-licence holding and thus the availability of private vehicles for lift-sharing schemes (Chatterjee et al., 2018). Similarly, increased variation in working patterns over the day both poses challenges to individuals in securing access to appropriate patterns of mobility yet may also provide facilitation insofar as it may maximally use shared assets that may otherwise saturate during existing peak travel hours and lie redundant throughout the rest of the day. In conclusion then, ageing, urbanisation, the decline of driving in the young and changing patterns of work provide need–sharing opportunity couplets. This is not to say that sharing is necessarily the whole of the solution but in concert with private ownership and improved public transport, there is clear potential for shared travel to contribute more as part of the future transport mix. In this way, sharing modes that currently might be perceived as inflexible can instead be promoted as a suite of measures that look to reflect both habit (Middleton, 2011) and 'household elasticity' (Rau & Sattlegger, 2018). Finally, in the case of the increasing acceptability of the sharing economy in general, in which transport may be just a small part, clearly if this change is genuine and persists, it would be a major facilitator of future transport-sharing schemes. However, we suggest some caution is applied to whether this would necessarily extend to transport sharing. Many of the other services where 'access not ownership' applies do not share the characteristic of rivalry with transport sharing. By contrast, watching a film on Netflix or listening to music on Spotify is non-rivalrous (Geisler, 2005), in that we do not deprive someone else of the opportunity of watching or listening to the same media. Non-rivalrous sharing is therefore much easier to accept since it does not induce concern over accessibility and quality of access to the assets in question. Furthermore, and again as noted earlier, the profile of travel sharers in general (especially 'supersharers') has some overlap with the profile of early adopters across many forms of technology and activity: risk-taking educated males in urban areas. It is unclear both whether this will transition to a retained interested in transport sharing later in life and whether indeed transport sharing (and reduced driving too) genuinely reflect changing values and freely made choices, or whether this has been adopted only as a coping strategy in the face of economic pressures.

7. Conclusions

Shared transport is diverse. The shared transport ecosystem encompasses a wide diversity of approaches, implementation and modes and may be differentiated in terms of forms of: sharing, ownership, payment, degree of exclusivity/rivalry, technology pattern, functional range and usage pattern. Some similarity is shown across modes reflected in factors such as demographics and monetisation, particularly for car- and cycle-sharing schemes, although the level of diversity available also implies potential for future innovation in the sector. Shared travel can therefore be supported by a blend of specific (e.g., availability of public space for 'docked' bicycles) and perhaps more general policy measures (e.g. support for encouraging sharing in general as a recognised mode of human and economic activity in regulatory and taxation frameworks). Diversity includes technological and sharing mode diversity, not just transport mode diversity and different submodes will expand or contract at different rates, again emphasising the need for potentially different measures (or at least expectations) and for policy, developers and innovators to see where emerging forms of sharing fit within an overall picture.

In the section on shared travel modes, we gave indicative current figures of shared travel, although we share the view of other authors on this topic that the research base on shared travel is generally lacking (Chatterjee et al., 2018). We also noted that the importance of technological trends and decision-making on the inclination to share travel, were also factors that would have a bearing on subsequent use. Having discussed these additional factors, we now offer some predictions. The paucity of data on current shared modes prevents numerical estimates but it is possible to predict some trends .

Generally, if we take shared travel overall, we predict an overall increase. The availability of new technologies for peer-to-peer micro- and contactless payments will ease remuneration for travel. Increased penetration and quality of positioning technologies will allow better positioning of people, shared transport assets and integration with public transport. MaaS can also play a role in integrating shared travel within an end-to-end journey. Social trends also make sharing more conducive. Decreasing car ownership in younger users, an ageing population with reduced ability to drive, and migration to urban environments with lower car ownership and higher density of living and infrastructure which shorten travel times to shared travel assets (e.g. bike stands), will all drive shared travel.

However, we predict that increases within shared travel will be modest. Most journeys supported by shared travel tend to be short. The availability of public transport in (sub)urban environments, the practicalities of the private car (which may even be enhanced by electrification and autonomy), and the general lack of adoption of shared travel for long-distance trips, mean the increase in shared travel both in the number of journeys made, and particularly in terms of the miles travelled, is likely to be small. We also note that the length of trip means that policy levers must be applied at a local or regional level, and that the role of third parties in the market, particularly for cycles or community buses, might fragment rather than cement the market.

We predict differential rates of growth for different forms of shared travel:

- **Lift sharing** is likely to be stable. Platforms such as Facebook and matching technologies have failed to generate new pools of users, and the desire to have a solo journey, plus the complexities of both driver and passengers having to negotiate and adapt their journeys, mean that uptake is unlikely to change radically.

- **Car-club** usage is likely to increase substantially. Faster micropayment mechanisms, the shift away from car ownership and (within a 2040 timescale) the potential for a reduced need to have a licence (applying both to the young and older drivers) predict greater demand for short-term car usage. The opportunity to fit payment or journey planning within MaaS programmes also presents a natural means to publicise such a service. It is unlikely that this will be generated by peer-to-peer as major players are likely to expand into this market.

- **Cycle sharing** is likely to increase substantially. The period 2010 to 2016 saw the cycle-hire scheme in London increase from 100,000 users and 2.5 million trips (Ogilvie & Goodman, 2012) to 600,000 users and 10.3 million trips (DfT, 2017). It is reasonable to assume that this will growth will not only continue, but also be seen as other schemes develop in other cities. Critically, investment in all forms of cycling infrastructure (e.g., Nottingham West Bike Corridor; TfL cycle superhighways) benefits all cycle users, making it an appealing mode. It applies to a wide age range, and supports travel in an urban environment. Increasing use of geofenced (rather than completely unrestrained) docking, and contactless payments, decrease the effort of this mode, which suits modest trips in an urban environment.

- **Taxi sharing** is likely to be stable or decline. The availability of Uber, or other cheap forms of taxi, and the growing potential of car-club schemes mean that there is little need for shared taxi services other than at specific locations or times. The potential of low-cost, autonomous vehicles is also likely to prove an attractive alternative to taxi sharing.

- **Bus sharing** such as community bus services may remain stable. There are potentially some spaces in the market for crowdfunded coaches, but at scale, community bus services look likely to remain the province of the volunteer-provided service. The arrival of autonomous transport would be more likely to support car schemes and individual or small-group ridership than bus travel.

In summary, there are two streams of sharing services:

- **Third-party services** where access is given to assets that are shared asynchronously by people (car club, bike share). While access may be shared, and there is no ownership, there is little need for people to actively coordinate. On the other hand, these services are more likely to be monetised. Overall, these services are providing an alternative to private ownership, and are likely to grow, reflecting greater urbanisation. Rather than being limited by people's flexibility of travel choices, such services offer a way to extend and complement travel

choices (e.g. bike share for first and last mile connections to public transport). Currently, they are of most interest to affluent males, but with careful management they could increase in appeal to a wider segment. Also, as electric and automated vehicles come on line, they offer greater reach into suburban environments.

- **Peer-to-peer services** where people actively coordinate to share a travel resource. Currently, we see potential for only modest growth in this area. The advance of ICT in this area has not seen substantial gain, and there are still more fundamental questions of trust, coordination and the social effort and perceived risk required to form new sharing relationships, particularly for travel that involves both nuanced activities and a need to share space. Social groups cannot be artificially constructed, but where there are existing social groups, there is some opportunity for growth, although this needs policy support for ongoing support and coordination.

Shared transport is sociotechnical and dynamic. It reflects the complete system at play rather than narrow instrumental decision-making. This includes the mechanisms for selecting the journey and fellow sharers, the personal context and needs of the traveller both individually and for peer-to-peer sharing, and the social context. Sharing decisions may evolve throughout an individual's life, reflecting changes in circumstances, activity and geography, both as gradual change and in response to life events, intersecting with established habits and varying incentives. Thus, other social trends (ageing, changing working patterns, growth of cities) will affect the future of sharing by stimulating new patterns of demand. In this view then, a 'build it and they will come' technology or market-driven approach may not be successful, and shared transport schemes in general have proved difficult to get right with a relatively high rate of market failure (often encountered as the failure of an otherwise 'good idea' to achieve critical mass). As an alternative, a genuinely user-driven shared transport policy approach could be adopted that looks at the mobility needs of different demographic groups and their habits, practices and constraints, and considers how to meet these travel requirements and aspirations using shared options in concert with public transport. Automated and connected vehicles offer significant potential to change the transport landscape. But if user driven, then schemes involving them should be implemented in a way that genuinely addresses people's needs and concerns (as well as technological ambitions). Then schemes can be successful as a vector for encouraging further transport sharing rather than replacing one form of private vehicle with another. Consequently, a human-centred view of sharing should be a contributor to emerging policy around regulation, business and technology itself in automated and connected vehicles. Finally, people change, circumstances change, and knowledge, experience and familiarity with transport grows over time. Therefore, transport is dynamic, and support needs to be ongoing rather than simply an initial investment to launch a scheme.

Sharing is a human activity even when mediated by technology. While much informal transport sharing goes on (and perhaps always has), the focus has moved to systems that harness digital technology to assemble new sharing communities, broker sharing arrangements and payments, and allow individuals to discover, plan and arrange shared travel. Innovative technology (e.g. NFC used to access free-floating bikes and cars) may also facilitate new forms of sharing. However, this does

not in itself remove concerns such as loss of control and freedom, social awkwardness about sharing, and concerns about personal safety. There is some evidence that some of these concerns may be addressed by familiarity with and the normalisation of the sharing economy, and we foresee some potential in innovative recent technology (e.g. connected cars that share telemetry). Studies also show that the provision of information through non-functional elements of sharing applications may also be crucial (e.g. ability to communicate with fellow sharers if required, clear route maps, certainty about costs). Overall, this suggests that usability and concern for the needs of a diverse user base are key ingredients of a successful ICT-based sharing service, not an optional extra, and should be identified as a major strategic aim by would-be providers.

Shared transport works best when supported by a solid public transport offer. Shared transport may best fulfil its potential as part of a connected end-to-end journey rather than as a complete replacement for public or private options; indeed the evidence suggests that *public transport is the key enabler of shared transport.* Shared transport may facilitate progress in meeting environmental policy aims as well as supporting greater general mobility of citizens. One way to further locate and promote shared transport within the wider world of travel is to ensure that it is practically supported in moves towards MaaS platforms (i.e. present on platforms, with a diversity of shared travel options represented in APIs and data formats). One key factor within MaaS may also prove to be reciprocity of data between stakeholders.

8. References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes* 50, pp. 179–211.

Altoonative Travel (n.d.). *welcome to altoonative travel… make a better journey your goal.* Available at: http://www.altoonativetravel.com/

Anable, J. (2005). 'Complacent car addicts' or 'aspiring environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport Policy* 12(1), pp. 65–78.

Anable, J. & Gatersleben, B. (2005). All work and no play. The role of instrumental and affective factors in work and leisure journeys by different travel modes. *Transportation Research Part A: Policy and practice* 39(2), pp. 163–181.

APTA (2016). *Shared mobility and the future of public transit.* Available at: https://www.apta.com/resources/reportsandpublications/Documents/APTA-Shared-Mobility.pdf [accessed 16 Jun 2018].

BBC (2016). *How BlaBlaCar created a global transport network.* Available at: http://www.bbc.co.uk/news/business-38597504

Bamberg, S., Ajzen, I. & Schmidt, P. (2003). Choice of travel mode in the theory of planned behavior: the roles of past behavior, habit, and reasoned action. *Basic and Applied Social Psychology* 25(3), pp. 175–187.

Barnard, Y., Bradley, M. D., Hodgson, F. & Lloyd, A. D. (2013). Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability. *Computers in Human Behavior* 29, pp. 1715–1724.

Belk, R. (2014). You are what you can access: Sharing and collaborative consumption online. *Journal of Business Research* 67(8), pp. 1595–1600.

Benkler, Y. (2004). Sharing Nicely: On Shareable Goods and the Emergence of Sharing as a Modality of Economic Production. *Yale Law Journal* 114, pp. 273–358.

Bissell, D. (2014). Transforming commuting mobilities: the memory of practice. *Environment and Planning A* 46(8), pp. 1946–1965.

Blablacar, (n.d.). Blablacar website. Available at: https://www.blablacar.co.uk/

Böcker, L. & Meelen, T. (2017). Sharing for people, planet or profit? Analysing motivations for intended sharing economy participation. *Environmental Innovation and Societal Transitions* 23, pp. 28–39.

Botsman, R. & Rogers, R. (2010). Beyond Zipcar: Collaborative consumption. *Harvard Business Review* 88(10), p. 30.

Brereton, M. & Ghelewat, S. (2010). *Designing for participation in local social ridesharing networks: grass roots prototyping of IT systems*. In Proceedings of the 11th Biennial Participatory Design Conference, Sydney, Australia, 29 November – 3 December, pp. 199–202.

Brown, B. B., Werner, C. M. & Kim, N. (2003). Personal and contextual factors supporting the switch to transit use: evaluating a natural transit intervention. *Analyses of Social Issues and Public Policy* 3(1), pp. 139–160.

Buliung, R., Soltys, K., Habel, C. & Lanyon, R. (2009). Driving factors behind successful carpool formation and use. *Transportation Research Record: Journal of the Transportation Research Board* 2118, pp. 31–38.

Buliung, R. N., Soltys, K., Bui, R., Habel, C. & Lanyon, R. (2010). Catching a ride on the information super-highway: toward an understanding of internet-based carpool formation and use. *Transportation* 37(6), pp. 849–873.

Calvo, R. W., de Luigi, F., Haastrup, P. & Maniezzo, V. (2004). A distributed geographic information system for the daily car pooling problem. *Computers & Operations Research* 31(13), pp. 2263–2278.

Car2go (n.d.). Daimler, car2go website. Available at. https://www.daimler.com/products/services/mobility-services/car2go/ [accessed 16 Jun 2018].

Car Next Door (n.d). Car next door website. Available at: www.carnextdoor.com.au

Caulfield, B. (2009). Estimating the environmental benefits of ride-sharing: a case study of Dublin. *Transportation Research D* 14(7), pp. 527–531.

Centre for Connected & Autonomous Vehicles (2016). *Pathways to driverless cars: Insurance for automated vehicles (Impact Assessment)*. Available at: https://www.parliament.uk/documents/impact-assessments/IA17-008A.pdf

Centre for Connected & Autonomous Vehicles (2017a). *UK connected and autonomous vehicle research and development projects 2017*. Available at: https://www.gov.uk/government/publications/connected-and-autonomous-vehicle-research-and-development-projects-2017

Centre for Connected & Autonomous Vehicles (2017b). *Pathways to driverless cars consultation on proposals to support advanced driver assistance systems and automated vehicles technologies: Government response.* Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/581577/pathway-to-driverless-cars-consultation-response.pdf

Chan, N. D. & Shaheen, S. A. (2012). Ridesharing in North America: Past, present, and future. *Transport Reviews* 32(1), pp. 93–112.

Chatterjee, J., Goodwin, P., Schwanen, T., Clark, B., Jain, J., Melia, S., Middleton, J., Plyushteva, A., Ricci, M., Santos, G. & Stokes, G. (2018). *Young people's travel –*

What's changed and why? Review and analysis. Report to Department for Transport. University of the West of England, Bristol, UK. Available at https://www.gov.uk/government/publications/young-peoples-travel-whats-changed-and-why

Citiscope (2016). *Why Helsinki's innovative on-demand bus service failed.* Available at http://citiscope.org/story/2016/why-helsinkis-innovative-demand-bus-service-failed

Citylab (2017). *The Four Horsemen of the Bike Share Apocalypse*. Available at https://www.citylab.com/transportation/2017/01/seattle-bike-share-pronto-goes-under/513575

Costain, C., Ardron, C. & Habib, K. N. (2012). Synopsis of users' behaviour of a carsharing program: a case study in Toronto. *Transportation Research Part A* 46, pp. 421–434.

Co-Wheels (n.d.). Co-Wheels car club website. Available at: http://www.co-wheels.org.uk/northeast

Cox, T., Houdmont, J. & Griffiths, A. (2006). Rail passenger crowding, stress, health and safety in Britain. *Transportation Research Part A: Policy and Practice* 40(3), pp. 244–258.

Cranwell, J., Golightly, D., Fischer, J., Sharples, S. & O'Malley, C. (2012). Using mobile applications that combine self-report micro surveys to enhance GPS tracking data. *International Journal of Psychology of Education and Assessment* 11(1), pp. 55–74.

d'Orey, P. M., Fernandes, R. & Ferreira, M. (2012). *Empirical evaluation of a dynamic and distributed taxi-sharing system.* Proceedings of the 15th International IEE Conference on Intelligent Transportation Systems, Anchorage, Alaska, 16–19 September, pp. 140–146.

Dailey, D. J., Loseff, D. & Meyers, D. (1999). Seattle smart traveler: dynamic ridematching on the World Wide Web. *Transportation Research Part C* 7(1), pp. 17–32.

Delhomme, P. & Gheorghiu, A. (2016). Comparing French carpoolers and non-carpoolers: Which factors contribute the most to carpooling?. *Transportation Research Part D: Transport and Environment* 42, pp. 1–15.

Dickinson, J. E., Filimonau, V., Cherrett, T., Davies, N., Hibbert, J. F., Norgate, S. & Speed, C. (2017). Lift-share using mobile apps in tourism: the role of trust, sense of community and existing lift-share practices. *Transportation Research Part D: Transport and Environment*, in press.

DfT (2006). *Travel Advisory Leaflet: High Occupancy Vehicle Lanes.* London: Department for Transport. Available at http://www.ukroads.org/webfiles/TAL%203-06%20High%20Occupancy%20Vehicle%20Lanes.pdf

DfT (2011). *Personal Travel Factsheet: Commuting and business travel.* London: Department for Transport. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230553/Commuting_and_business_travel_factsheet___April_2011.pdf

DfT (2015). *The pathway to driverless cars: summary report and action plan*. London: Department for Transport. Available at https://www.gov.uk/government/publications/driverless-cars-in-the-uk-a-regulatory-review

DfT (2016a) *Annual bus statistics: England 2015/16* London: Department for Transport. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/579855/annual-bus-statistics-year-ending-march-2016.pdf

DfT (2016b). *How people travel (NTS03): Table NTS0305 Average distance travelled by mode: England.* London: Department for Transport. Available at https://www.gov.uk/government/statistical-data-sets/nts03-modal-comparisons#table-nts0305

Fellows, N. T. & Pitfield, D. E. (2000). An economic and operational evaluation of urban car-sharing. *Transportation Research Part D* 5(1), pp. 1–10.

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), pp. 1654–1672.

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

Fishman, E., Washington, S., Haworth, N. & Mazzei, A. (2014). Barriers to bikesharing: An analysis from Melbourne and Brisbane. *Journal of Transport Geography* 41, pp. 325–337.

Freudendahl-Pedersen, M. & Kesselring, S. (2018). Sharing mobilities. Some propaedeutic considerations. *Applied Mobilities,* pp.1–7.

Friman, M. & Gärling, T. (2001). Frequency of negative critical incidents and satisfaction with public transport services. *Journal of Retailing and Consumer Services* 8(2), pp. 105–114.

Gardner, B. & Abraham. C. (2007). What drives car use? A grounded theory analysis of commuters' reasons for driving. *Transportation Research Part F* 10(3), pp. 187–200.

Gärling, T., Jakobsson, C., Loukopoulos, P. & Fujii, S. (2004). Roles of information technology in households' adaptation of private car use to travel demand management measures. *Journal of Intelligent Transportation Systems* 8, pp. 189–194.

Gargiulo, E., Giannantonio, R., Guercio, E., Borean, C. & Zenezini, G. (2015). Dynamic ride sharing service: are users ready to adopt it?. *Procedia Manufacturing* 3, pp. 777–784.

Giesler, M. (2006). Consumer gift systems. *Journal of Consumer Research* 33(2), pp. 283-290.

Golightly, D., Sharples, S., Irune, A., Leygue, C., Cranwell, J. & O'Malley, C. (2010). *User and organisational needs for ad-hoc car sharing*. Proceedings of Digital Futures 2010. Available at https://www.horizon.ac.uk/students/images/stories/Students/dg-allhands_shortjc.pdf

Goodman, A. & Cheshire, J. (2014). Inequalities in the London bicycle sharing system revisited: Impacts of extending the scheme to poorer areas but then doubling prices. *Journal of Transport Geography* 41, pp. 272–279.

Government Office for Science (2016). *Future of an ageing population*. Norwich, UK: HMSO. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/535187/gs-16-10-future-of-an-ageing-population.pdf

Gustafson, P. (2012). Travel time and working time: What business travellers do when they travel, and why. *Time & Society* 21(2), pp. 203–222.

Haas, B. (2017). Chinese bike share graveyard a monument to industry's 'arrogance'. *The Guardian* 25 November. Available at: https://www.theguardian.com/uk-news/2017/nov/25/chinas-bike-share-graveyard-a-monument-to-industrys-arrogance

Habib, K. M. N., Morency, C., Islam, M. T. & Grasset, V. (2012). Modelling users' behaviour of a carsharing program: Application of a joint hazard and zero inflated dynamic ordered probability model. *Transportation Research Part A: policy and practice* 46(2), pp. 241–254.

Haines, H., Wilson, J. R., Vink, P. & Koningsveld, E. (2002). Validating a framework for participatory ergonomics (the PEF). *Ergonomics* 45(4), pp. 309–327.

Harvey, J., Smith, A. & Golightly, D. (2014). Giving and sharing in the computer-mediated economy. *Journal of Consumer Behaviour* 16, pp. 363–371.

Harvey, J., Smith, A. & Golightly, D. (2017, in press). Online technology as a driver of sharing. To appear in P. Albinsson (ed.) *Sharing Economy: Opportunities, Challenges and the Way Forward*. Praeger.

Harvey, J., Smith, A. & Golightly, D. (2018). Sharing and Reciprocity: A social network analysis of non-monetary exchange. Submitted to *Journal of Management Science*.

Hoffman, R. R. & Woods, D. D. (2000). Studying cognitive systems in context: Preface to the special section. *Human Factors* 42(1), pp. 1–7.

ITP (2010). *Regional Rural Car Share Feasibility Study*. Consultancy report available on request.

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

Kelestyn, B., Henfridsson, O. & Nandhakumar, J. (2017). *Scaling the user base of digital ventures through generative pattern replication: The case of ridesharing*, Proceedings of the 50th Hawaii International Conference on System Sciences 4–7 January, Waikoloa, HI.

Kenyon, S. & Lyons, G. (2003). The value of integrated multimodal information and its potential contribution to modal change. *Transportation Research Part F*: *Traffic Psychology and Behaviour* 6(1), pp. 1–21.

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal* 79(1), pp. 1–14.

Kopp, J., Gerike, R. & Axhausen, K. W. (2013). Status quo and perspectives for car-sharing systems: the example of DriveNow. *Strategies for Sustainable Mobilities: Opportunities and Challenges*, pp. 207–226.

Klein, G. (2008). Naturalistic decision making. *Human Factors* 50(3), pp. 456–460.

Kopp, J., Gerike, R. & Axhausen, K. W. (2015). Do sharing people behave differently? An empirical evaluation of the distinctive mobility patterns of free-floating car-sharing members. *Transportation* 42(3), pp. 449–469.

Kurup, S., Golightly, D., Clarke, D. & Sharples, S. (2017) *Ride Along: Expertise and information use during rail travel.* Proceedings of 6th Rail Human Factors Conference, London, 6–9 November.

Lamberton, C. P. & Rose, R. L. (2012). When is ours better than mine? A framework for understanding and altering participation in commercial sharing systems. *Journal of Marketing* 76(4), pp. 109–125.

Laurier, E., Lorimer, H., Brown, B., Jones, O., Juhlin, O., Noble, A. & Swan, L. (2008). Driving and 'passengering': Notes on the ordinary organization of car travel. *Mobilities* 3(1), pp. 1–23.

Liftshare (n.d.). *Liftshare website*. Available at: https://liftshare.com/uk

Liu, T. & Ceder, A. A. (2015). Analysis of a new public-transport-service concept: Customized bus in China. *Transport Policy* 39, pp. 63–76.

Lovejoy, K. & Handy, S. (2011). Social networks as a source of private-vehicle transportation: The practice of getting rides and borrowing vehicles among Mexican immigrants in California. *Transportation Research Part A* 45(4), pp. 248–257.

Lyons, G. & Chatterjee, K. (2008). A human perspective on the daily commute: costs, benefits and trade-offs. *Transport Reviews* 28(2), pp. 181–19.

Ma, S., & Wolfson, O. (2013, November). *Analysis and evaluation of the slugging form of ridesharing*. Proceedings of the 21st ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems, Orlando, USA, 5–8 November, pp. 64-73.

Ma, S., Zheng, Y. & Wolfson, O. (2015). *Real-time city-scale taxi ridesharing*. *IEEE Transactions on Knowledge and Data Engineering* 27(7), pp. 1782–1795.

Malodia, S. & Singla, H. (2016). A study of carpooling behaviour using a stated preference web survey in selected cities of India. *Transportation Planning and Technology* 39(5), pp. 538–550.

Mann, E. & Abraham, C. (2006). The role of affect in UK commuters' travel mode choices: An Interpretative Phenomenological Analysis. *British Journal of Psychology* 97, pp. 155–176.

Mauss, M. (2000/1925). *The Gift: Forms and Functions of Exchange in Archaic Societies*.

Merat, N., Madigan, R. & Nordhoff, S. (2017). *Human factors, user requirements and user acceptance of ride-sharing in automated vehicles.* Discussion Paper No. 2017-10, Cooperative Mobility System and Automated Driving, International Transport Forum/OECD.

Middleton, J. (2011). 'I'm on Autopilot, I Just Follow the Route': Exploring the habits, routines, and decision-making practices of everyday urban mobilities. *Environment and Planning A* 43(12), pp. 2857–2877.

Morency, C. (2007). The ambivalence of ridesharing. *Transportation* 34, pp. 239–253.

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

Netimperative (2016). *Digital divide: 7.5m Brits left behind in the digital revolution.* Available at: http://www.netimperative.com/2016/07/digital-divide-7-5m-brits-left-behind-digital-revolution/

Nielsen, J. R., Hovmøller, H., Blyth, P. L. & 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, pp. 113–123.

Nottingham University (n.d.). *Carsharing*. Available at www.nottingham.ac.uk/sustainability/transport/carsharing.aspx

Ofcom (2017). *Adults' media use and attitudes report 2017.* Available at https://www.ofcom.org.uk/__data/assets/pdf_file/0020/102755/adults-media-use-attitudes-2017.pdf

Ofo (n.d.). Ofo website. Available at: http://www.ofo.com/#/

ONS (2016). *Population dynamics of UK city regions since 2011*. Norwich, UK: HMSO. Available at https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/populationdynamicsofukcityregionssincemid2011/2016-10-11

Ogilvie, D. & Goodman, A. (2012). Inequities in usage of a public bicycle sharing scheme: Socio-demographic predictors of uptake and usage of the London (UK) cycle hire scheme. *Preventive Medicine* 55(1), pp. 40–45

Ostrom, E. (2003). How types of goods and property rights jointly affect collective action. *Journal of Theoretical Politics* 15(3), pp. 239–270.

Palacin, R., Vigar, G. & Peacock, S. (2016). Transport poverty and urban mobility. In S. Davoudi & D. Bell (eds), *Justice and Fairness in the City: A Multidisciplinary Approach to 'ordinary' Cities*. Bristol: Policy Press, pp. 69–79.

Passenger Transport (2015). Arriva partners with BMW for car sharing. Available at http://www.passengertransport.co.uk/2015/08/arriva-partners-with-bmw-for-car-sharing/

Rau, H. & Sattlegger, L. (2018). Shared journeys, linked lives: a relational–biographical approach to mobility practices. *Mobilities* 13(1), pp. 45–63.

Remland, M. S., Jones, T. S. & Brinkman, H. (1995). Interpersonal distance, body orientation, and touch: Effects of culture, gender, and age. *Journal of Social Psychology* 135(3), pp. 281–297.

Sattlegger, L. & Rau, H. (2016). Carlessness in a car-centric world: A reconstructive approach to qualitative mobility biographies research. *Journal of Transport Geography* 53, pp. 22–31.

Schwanen, T., Banister, D. & Anable, J. (2011). Scientific research about climate change mitigation in transport: A critical review. *Transportation Research Part A: Policy and Practice* 45(10), pp. 993–1006.

Seethaler, R. & Rose, G. (2006). Using the six principles of persuasion to promote travel behavior change: Findings of a TravelSmart pilot test. *Transport Research Record* 1956, pp. 42–51.

Shaheen, S., Cohen, A. & Chung, M. (2009). North American carsharing: 10-year retrospective. *Transportation Research Record: Journal of the Transportation Research Board* 2110, pp. 35–44.

Shannon, T., Giles-Corti, B., Pikora, T., Bulsara, M., Shilton, T. & Bull, F. (2006). Active commuting in a university setting: assessing commuting habits and potential for modal change. *Transport Policy* 13(3), pp. 240–253.

Shanteau, J. (1988). Psychological characteristics and strategies of expert decision makers. *Acta Psychologica* 68(1–3), pp. 203–215.

Shao, J. & Greenhalgh, C. (2010). *DC2S: a Dynamic Car Sharing System*. ACM LBSN '10, Proceedings of the 2nd ACM SIGSPATIAL International Workshop on Location Based Social Networks, San Jose, CA, USA, 2 November.

Sharples, S., Golightly, D., Leygue, C., O'Malley, C., Goulding, J. & Bedwell, B. (2012). Technologies to Support Socially Connected Journeys: Designing to encourage user acceptance and utilisation. In D. de Waard, N. Merat, A. H. Jamson, Y. Barnard & O. M. J. Carsten (eds) (2012). *Human Factors of Systems and Technology*. Maastricht, The Netherlands: Shaker Publishing.

Shove, E. (2010). Beyond the ABC: climate change policy and theories of social change. *Environment and Planning A* 42(6), pp. 1273–1285.

Sn-ap (n.d.) Sn-ap website. Available at: https://www.getasnap.com/

Spinney, J. & Lin, W. I. (2018). Are you being shared? Mobility, data and social relations in Shanghai's Public Bike Sharing 2.0 sector. *Applied Mobilities*, pp.1–18.

Steg, L. (2005). Car use: lust and must. Instrumental, symbolic and affective motives for car use. *Transportation Research Part A: Policy and Practice* 39(2), pp. 147–162.

Sun, X., Golightly, D., Sharples, S. & Bedwell, B. (2012). User requirements and constraints for on-demand taxi sharing technology. *Contemporary Ergonomics and Human Factors*, pp. 409–416.

Sun, Y., Mobasheri, A., Hu, X. & Wang, W. (2017). Investigating impacts of environmental factors on the cycling behavior of bicycle-sharing users. *Sustainability* 9(6), p. 1060.

TfL (2017). *Licensing decision on Uber London Limited.* Available at https://tfl.gov.uk/info-for/media/press-releases/2017/september/licensing-decision-on-uber-london-limited

TfL (2017). *Record breaking year for Santander cycles.* Available at https://tfl.gov.uk/info-for/media/press-releases/2017/february/record-breaking-year-for-santander-cycles

TfN (2018). *Strategic transport plan.* Available at http://transportforthenorth.com/wp-content/uploads/TfN-Strategic-Plan_draft_lr.pdf

Thebault-Spieker, J., Terveen, L. G. & Hecht, B. (2015). Avoiding the south side and the suburbs: The geography of mobile crowdsourcing markets. Proceedings of the

18th ACM Conference on Computer Supported Cooperative Work & Social Computing, pp. 265–275.

Transport Systems Catapult (2015). *Travellers' Needs Study.* Available at https://ts.catapult.org.uk/current-projects/traveller-needs-uk-capability-study/

Transport Systems Catapult (2016). *Mobility As A Service: Exploring the opportunity for mobility as a service in the UK*. Available at: https://ts.catapult.org.uk/wp-content/uploads/2016/07/Mobility-as-a-Service_Exploring-the-Opportunity-for-MaaS-in-the-UK-Web.pdf

Transport Systems Catapult (2017). *Market forecast for connected and autonomous vehicles.* Available at: https://www.gov.uk/government/publications/connected-and-autonomous-vehicles-market-forcecast

Transport Extra (2016). *Car-share lifts off at Heathrow Airport*. Available at https://www.transportxtra.com/publications/parking-review/news/50125/car-share-lifts-off-at-heathrow-airport

UK Commission for Employment and Skills (2014). *The future of work: Jobs and skills in 2030*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/303335/the_future_of_work_key_findings_edit.pdf

Usability Matters (2017). *10 stats that demonstrate UX matters.* Available at https://usabilitymatters.com/10-stats-demonstrate-roi-ux/

Van Excel, J. & Rietveld, P. (2009). Could you also have made this trip by another mode? An investigation of perceived travel possibilities of car and train travellers on the main travel corridors to the city of Amsterdam. *Transportation Research Part A: Policy and Practice* 43(4), pp. 374–385.

Wash, R., Hemphill, L. & Resnick, P. (2005). *Design decisions in the RideNow project*. Proceedings of the 2005 International ACM SIGGROUP Conference on Supporting Group Work, Sanibel Island, Florida, USA, 6–9 November, New York: ACM Press.

Wilson, J. R. & Sharples, S. C. (2015) *Methods in the understanding of human factors*. In J. R. Wilson & S. Sharples (eds), *Evaluation of human work* 4th ed., CRC Press, pp. 1–32.

YouGov (2016). *How loyal are online sharing economy customers?.* Available at https://yougov.co.uk/news/2016/06/07/sharing-economy/

Zimmer, J. (2016). *The third transport revolution: Lyft's vision for the next ten years and beyond*. Available at https://medium.com/@johnzimmer/the-third-transportation-revolution-27860f05fa91

Zipcar (2016). Zipcar drives past million member milestone. Available at http://www.zipcar.co.uk/press/releases/zipcar-drives-past-million-member-milestone

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