New technologies for the old: Potential implications of living in later life for travel demand ☆

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ABSTRACT

Assistive technologies for older people, such as personal tracking devices and community alarms, can facilitate living independently for longer. Where and how older people live will affect patterns of travel associated with their lifestyles and needs. They may remain in their own homes, those of relatives or in residential care homes. They may make minimal or extensive use of technologies. As such, assistive technologies represent an example of technological developments and their social uptake *outside* the field of transport. Such developments may, nevertheless, have an *indirect* impact on travel demand and one which may be quite substantial. This paper aims, through a series of expert interviews, to examine: (i) to what extent the mobility effects of technological developments (outside transport) are being considered within the transport sector; (ii) how important or relevant it is for such consideration to be given; and (iii) ways in which such impacts can be accounted for in travel demand analysis and policy decisions. What emerges is that such indirect impacts are considered very important but rarely are they examined. The transport experts interviewed noted various ways of increasing the integration between transport and other domains. Several saw more emphasis on these issues in the education of transport professionals as an important starting point. The paper concludes with the case for using scenario planning as a means to emphasise how the living arrangements for older people, facilitated through assistive technologies, could produce distinct and significant consequences for travel demand.

1. Introduction

Personal travel is generally understood to be a derived demand. It is a means to an end, the end being the opportunity to participate in activities at the destination. It follows that travel demand is strongly related to developments in other sectors, such as employment, retail, leisure or healthcare. These influence the activities people need or want to perform, and where they perform them (Stead and Banister, 2001). Travel demand is likely to change following alterations in the activities people perform and *how* they perform them (Hubers and Lyons, 2013). Since technologies play a key role in the performance of human activities, technological change (often stemming from outside the transport domain) has the potential to *indirectly* influence travel demand through changing social practices. In this article we take 'social practices' to mean the ways in which people

individually and collectively construct and go about their daily lives in pursuit of their goals. The birth control pill, for example, has facilitated alterations in the practice of family formation and enabled more women to invest in their education and career. This in turn increased the number of commute trips by women. It possibly also contributed to the increased use of automotive modes as these are considered to be best suited to perform multi-purpose trips (e.g. paid work to daycare centre to super market to home, see Dowling, 2000).

In this paper we examine the matter of indirect relations between 'non-transport' technologies, social practices and travel demand. This is done through a focus on living in later life. Our interpretation of 'technology' is inspired by the writings of Arthur (2009). He, states that "a technology is *a means to fulfil a human purpose*" and that "[a]s a means, a technology may be a method or process or device" (Arthur, 2009, pp. 29). The focus is thus not solely on emerging artefacts or devices. It is also on the processes of designing these technologies and of making the resulting products and services available to people.

We assert that in order to understand past, present and future travel demands one needs to be able to take account of the technological shaping of social practices (and vice versa, the social shaping of technologies). It is far from clear that present day decision making by policymakers is well supported or supported

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at all by methods of examination that look to address such issues. Meanwhile decision making continues to be beset by unintended consequences. To illustrate some of the shortcomings implicit in decision making processes of policymakers, Lyons (2008) has examined the law of unintended consequences. He highlights a number of examples of transport policies with unintended consequences for transport and for other sectors and examples of non-transport policies with unintended consequences for transport. As Mollenkopf (2004), pp. 62 argues, "technical developments contain both the possibilities to expand one's scope of action and to perpetuate new dependencies and limitations." An illustration of this is as follows. The minimal physical effort needed to drive a car on the one hand enables older people to stay mobile. However, growing car use has also contributed to shops and other facilities being located further away from people's homes. This makes (older) people more dependent on a car to access these. As a result older people experience great difficulties in accessing these facilities once they are forced to give up driving (Musselwhite, 2011). The adoption and use of technologies almost always has unintended or unanticipated consequences (Fischer, 1992; Hubers and Lyons, 2013). The travel demands of older people living in their own homes will differ from those who live in residential or nursing homes (see also Burnett and Lucas, 2010). A non-transport policy of promoting independent living is therefore bound to have implications for transport.

There is a sense of urgency around the ageing of the population and the various kinds of consequences this may have—this has been our motivation to focus on living in later life. The Queen's Speech (2010) of 25 May setting out the legislative agenda for the UK Government mentioned the reform of social care for older and disabled people as being "one of the biggest challenges faced by society today". At the European level, the increased longevity and improved health of the European population is acknowledged as a huge and commendable achievement. However, a report commissioned by EU finance ministers on the long-term impact of ageing foresees major social, budgetary and economic challenges associated with it (European Commission and Economic Policy Committee, 2009). In addition, the 2011 European Commission Transport White Paper impact assessment addresses the possible implications of an ageing European population for the transport sector (European Commission, 2011). Both the increasing numbers of older people and people with a disability are key aspects in the projections for the transport sector discussed in the report, as are the consequences of an ageing labour force in the transport sector. Farber and Páez (2010) highlight similar concerns for North America and also note the tendency for the prevalence of disabilities to increase with age.

At present, one in six people in the UK is aged 65 or over and this will be one in four by 2050 with the over 85s forming the fastest growing group (Cracknell, 2010). Globally the number of people aged 65 or over is set to nearly triple by 2050 to 1.5 billion (NIA and WHO, 2011). Maintaining the wellbeing and quality of life of our ageing population is likely to require considerable changes in the way in which care is provided (Magnusson et al., 2005). High costs of residential care combined with the preference of older people to remain living in their own homes for as long as possible have cultivated not only the desire but also the need to 'age in place'. The demand for social care is estimated to increase by 44% over the next 20 years due to the anticipated increase in life expectancy, but importantly also because the *healthy* life expectancy is expected to lag behind the overall increase in life expectancy (Plum Consulting, 2010). It is deemed very unlikely that the formal care supplied by the state and informal care provided by friends and relatives will be able to meet this demand. Accordingly, much is expected of technology's potential to bridge the gap between supply and demand through helping more and more people to live in their own homes for longer

(Mahmood et al., 2008; Milligan et al., 2011; Rodeschini, 2011). As well as helping to compensate for health problems, technologies are hoped to assist active ageing—delaying the onset of health problems through maintaining a fulsome lifestyle. Assistive technologies have the potential to change the social practices of both older people and their carers—and in turn their travel demands. However, the ageing in place agenda is fraught with uncertainty. We do not know which technologies will become mainstream, and especially how they will come to be used and with what consequences for transport.

The goal of this paper is to explore the uncertainties related to emerging assistive technologies and their use and how these relate to mobility patterns in an ageing society. The relationship between assistive technologies and travel through their influence on social practices is explored. The paper also examines the extent to which account of this is or could/should be taken in current approaches to informing policy decisions. The paper is based on a series of 12 expert interviews involving senior individuals from the fields of ageing and transport.

The next section of the paper provides further context by framing the paper's contribution to the existing literature on ageing and mobility and possible changes in future travel demand. The interview methodology is then described before setting out the results of the interview analysis. The final section of the paper concludes by making the case for scenario planning. This is one important means of reconciling unavoidable uncertainties about the future with the need to offer some form of robustness of insight to inform present day policy decisions.

2. Current understandings of ageing and mobility

Probably one of the main causes of uncertainty around the future travel demand of older people is the general lack of detailed information on the mobility of older people. Indeed there is an accompanying paucity of insight concerning how disability affects people's travel (e.g. Farber and Páez, 2010; Rosenkvist et al., 2009; Lamont et al., 2013). However, at the moment we are witnessing an increasing interest in ageing and mobility (Schwanen and Páez, 2010) as well as ageing and access and inclusion (e.g. Titheridge et al., 2009). There is emphasis given to the distinction between individual or medical models of limitations faced by individuals (with a root cause of problems assumed to rest with the individual) and social models (which attribute limitations to the way systems and services are developed which then create limitations for particular individuals (Farber and Páez, 2010; and Titheridge et al., 2009). From this growing body of research we know that compared to younger cohorts, the mobility patterns of older people on average are characterized by fewer trips that are more often made by non-car transport modes, covering shorter distances (Schwanen et al., 2001; Rosenbloom, 2004; Mercado and Páez, 2009; Roorda et al., 2010) and with less trips made at night and some evidence to suggest that where car use takes place it is increasingly within the peak periods (Scott et al., 2009). However, these studies also emphasize that this average masks a great degree of diversity and heterogeneity in the mobility patterns of older people. Not all older people have disabilities but as noted earlier, disabilities tend to increase in prevalence with age. Ageing brings with it physical impairments affecting access to infrastructure (e.g. Hess, 2009). It also brings cognitive limitations such that people "can have difficulties orienting themselves in time and space, solving problems, organizing, expressing themselves verbally, remembering, etc." (Rosenkvist et al., 2009, pp. 66). This mix of different behaviours and circumstances amongst older people complicates the development of transport planning and policies for this population group (Metz, 2003). Safety issues surrounding older drivers have also become a focus area (Oxley et al., 2010), as

well as driving cessation. The latter can particularly be a problem for older people in rural areas who are often more dependent on the car due to a lack of public transport provision (Shergold and Parkhurst, 2010; Baster, 2012). Research on driving cessation has further highlighted the relation between mobility and wellbeing (Musselwhite and Haddad, 2010). This has itself become an important focus area of the literature on ageing and mobility (Banister and Bowling, 2004; Ziegler and Schwanen, 2011). The perceived positive relation between car driving and wellbeing has stimulated the development of Intelligent Transport Systems, such as in-vehicle technologies that aid the (older) driver in manoeuvring through the traffic. Furthermore, some have started to assess the robustness of the infrastructure systems – supporting older people living independently – to the impacts of disruptions resulting from climate change such as floods, heat waves or cold snaps (Oven et al., 2012).

Although considerable effort has been directed towards increasing our understanding of the mobility patterns of past and current generations of older people, the travel demand of *future* generations has received far less attention. A complicating factor is that as Arentze et al. (2008), pp. 614 argue, "it is not readily evident that current observations can be extrapolated to the future" since the mobility and activity patterns of future cohorts of older people are expected to be quite different from those of current cohorts (see also Coughlin, 2009). For example, because in the future a greater proportion of older people will have a driver's license, more of them may be used to a lifestyle based around the car (Alsnih and Hensher, 2003; Metz, 2003). It is therefore not only important to study the implications of the growth in the number and share of older people in the population, but also possible changes in their activity patterns. According to a study in the Netherlands, compared to older people in the year 2000, the activity patterns of older people in the year 2020 are expected to be characterised by the following. There will be increased labour participation and more engagement in out-of-home social and leisure activities. There will be rush hour avoidance as a result of which more trips are made after the morning peak hour and shifts in the residential location with more people aged 55–64 moving to low-density areas and people aged 65–74 moving in the opposite direction (Jorritsma and Olde Kalter, 2008). Scenario-based simulation models based on these assumptions show various temporal, modal and spatial shifts in older people's mobility patterns and a 3% increase in travel demand overall (Arentze et al., 2008).

Despite these efforts, there is a lot of uncertainty around the directions in which activity and travel patterns will develop as a result of the changing behaviour of future generations of older people. This paper focuses on one possible source of uncertainty: the relation between emerging assistive technologies and the changing activity and travel patterns of older people *and* their carers. Many trips undertaken in relation to older people tend not to be recognised as such. This is because they are undertaken by family members or other service providers (Alsnih and Hensher, 2003; for a thorough description of the close inter-relatedness of the mobility of the caregiver and the care recipient, see Wiles, 2003). The mobility patterns of formal or informal care and service providers and how these may be influenced by emerging assistive technologies have received limited attention (though see Magnusson et al. (2005) for some research on the impact of technologies on family carers of older people). As a result, the transport implications of an ageing society are likely to be underestimated.

3. Interview methodology

There is a lack of data that allows for the assessment of where and how older people will be living in the future and with what consequences for mobility. Interviewing was judged to be an appropriate method to explore this relationship and the possible role played by non-transport technologies. This method allows for an in-depth assessment of the possible intended and unintended or unanticipated implications these technologies may have for especially *how* older people will live and travel. Therefore, in order to form an understanding of the technological developments that are taking place around the care for older people and living in later life, six experts from the field of ageing in the United Kingdom (UK) were interviewed. The emphasis in these interviews was not so much on the specifics of the emerging technologies, but more on how the experts expected them to be used (perhaps in unanticipated ways) and how using them might relate to changing everyday activities and practices of older people and/or their carers. The ageing experts were also asked in what ways they thought the behaviour that might result from using particular technologies could impact on people's mobility.

A second set of six interviews involved experts from the field of transport in the UK who were also asked to think of technologies for ageing that might have an indirect impact on travel demand. With these assistive technologies in mind, they were then asked to consider: (i) the importance of considering such non-transport technologies within travel analysis; (ii) the extent (implicitly or explicitly) to which these are already considered; and (iii) why they might not be considered and how they could be. All 12 interviewees (see Table 1) are respected experts in their field and were identified either through prior personal contact or through recommendation.

Based on the feedback from piloting it was decided to provide interviewees with the main interview topics and questions in advance so that they could think of a technology beforehand around which to focus in the interview. The examples of technologies that were provided to interview participants in advance were all of technological artefacts. This may have resulted in a bias towards artefacts rather than methods or processes in the technology examples described by the interviewees. Nevertheless, changing methods and processes were also mentioned by the interviewees so there was no exclusive focus on artefacts. Because

Table 1
Background characteristics of interviewees.

Gender	Background
Ageing experts	
Male	Founder of independent research company whose work has centred on ageing, technology and independent living
Female	Head of innovation in a charity focusing on health and social care
Female	University professor and principal investigator on collaborative, cross-disciplinary research project on wearable assistive technologies
Male	Programme director with a global communications company, leading projects on enabling older people with communications technology
Male	University researcher developing technologies for promoting social connectedness
Male	University professor of gerontology with a special interest in ageing and technology
Transport experts	
Male	University professor and former senior civil servant from the UK Department for Transport
Male	University researcher on ageing and mobility
Female	Director of independent transport research and consultancy company
Male	University professor of transport
Female	Managing director in local government transport authority
Male	Former senior civil servant from the UK Department for Transport

of the exploratory nature of this study the interviews were semi-structured (Babbie, 1998; Kvale and Brinkmann, 2008; King and Horrocks, 2010). Where appropriate, interviewees were asked to reflect on issues that had come out of previous interviews.

All interviews were carried out by the first author. In one interview the second author participated as a co-interviewer. After each interview field notes were taken evaluating the interview itself and the general insights gained from it. Interviews lasted on average about 1 hour and 15 minutes. They were recorded and transcribed verbatim. A thematic analysis (Braun and Clarke, 2006) was then undertaken of the transcribed material. Key themes were identified through intensive (re-)reading of the transcripts by the first author. A description of these key themes accompanied by text segments representing these themes taken from the transcripts, was then discussed with the second author. To further improve the rigour of the analysis, the results were also compared to the findings of an informal focus group on the topic of non-transport technologies, ageing and mobility with other transport and ageing researchers working at the same research centre as the authors. All interviewees have given their consent for the interview contents to be used in our research with the level of anonymity applied.

4. Results

The interview findings are organised in a sequence of sub-sections reflective of the combined structuring of the two sets of interviews. The sequence also aligns with our emphasis on the three interacting matters of technologies, social practices and travel. We begin with an illustrative examination of emerging assistive technologies. This is important if we are to appreciate the art of the possible in terms of what technologies can support and enable. This is followed by considering how technology use relates to the needs and practices of older people. Bringing technologies and social practices together is a prerequisite to then exploring the possible transport consequences. Accounting for the effects of assistive technologies in terms of travel demand analysis is finally considered.

4.1. Emerging technologies—the art of the possible

Blaschke et al. (2009) provide a helpful context for this first part of our interview findings. In their review paper they note that "[c]onsiderable literature has appeared suggesting that Assistive Technologies (ATs) and Information and Communication Technologies (ICTs) may improve quality of life, extend length of community residence, improve physical and mental health status, delay the onset of serious health problems and reduce family and caregiver burden" (Blaschke et al., 2009, pp. 641). Pointing to the risk of an underlying 'simple optimism' in such suggestion, they conclude that "we are far from knowing what types of ATs and ICTs work well with what types of users under what conditions and for how long" (Blaschke et al., 2009, pp. 651). What diversity of possibility in terms of emerging technologies might then, at least, present itself in terms of this 'simple optimism'?

To address this, interviewees were invited to select and discuss emerging technologies that they thought were going to have an important impact on older people's health and wellbeing. This encompassed technological support of both physical and mental health and wellbeing alongside the role of technology in supporting the lives of those supporting older people. Technologies are evolving that provide functionality from monitoring individuals' vital signs, through tracking their movements to guiding them in their actions—both inside and outside of the home. These monitoring, tracking and/or guiding technologies serve multiple purposes. Some examples that were mentioned included: triggering a call for emergency care; monitoring and analysing the activities of an older person and providing them with prompts to help them in performing these activities independently. Further examples related to prevention through the development of diagnostic algorithms that can pinpoint whether movement patterns are slowing or needing more prompts which in turn may signal changing health conditions that warrant attention. Easy to use and high quality video interaction can supplement an individual's set of activities with further opportunity for interaction and engagement, ultimately increasing their wellbeing. The technologies are thus expected to counter an individual's deteriorating health, seek to prolong independent living and helping to prevent deterioration in health.

Relevant technologies extend beyond the electronic form to include for instance building design. One interviewee referred to involvement in a project working with architects designing larger, flexible dwellings. These had moveable internal walls (shuttering) to accommodate different household compositions at different life stages—from young children and teenagers through to elderly relatives. This could facilitate increases in inter-generational households if encouraged by other societal drivers such as cost of living.

Examples were also provided of emerging technologies as a process or method. The current process of providing older people with assistive technologies is governed by a limited range of standardised 'functional' products from specialised manufacturers. These constrain the capacity to accommodate the highly diverse and changing personal needs of older people (see Jorge (2001). The interviewees described a growing awareness of the importance of accommodating user needs into the design process of emerging products and services, moving beyond a simple 'technology push' approach (Milligan et al., 2011). Co-design, for example, engages with users in the design and development process. This can reveal what older people are *willing* to wear and use which can be at odds with designers' *presumptions* (see, for example, Muller, 2002; Blythe et al., 2005). Smart phones are epitomising new processes of technology design and service delivery. Technology artefacts are mass produced to set designs but these then provide platforms for highly flexible applications' development. This becomes manifest in what services users actually employ, with look, feel and functionality tailored to their needs and tastes.

Similarly, the system of care for older people overall might be seen as a form of technology or a process for which technology provides the enablers. This begins to point strongly towards the types of society and lifestyle that we are moving towards. On the one hand, there is the prospect of what is referred to as 'ageing in place'—remaining in one's own home or that of one's family. On the other is the reliance on residential institutions that provide homing and care for people as they grow older. The extent to which each of these prevail will both govern and be governed by the fortunes of assistive technologies.

The interviews reveal and underline the art of the possible in terms of technology making a contribution to the lives of older people. The march of modern technology is rapidly gaining pace as it penetrates the fabric of modern society. However, whether or not this is *incidental* or *instrumental* to how people lead their lives (in terms of where they live, what activities they participate in and what dependencies with others they have) is another matter. It is this which holds much greater significance for consideration of travel demand implications. We now move to briefly consider factors influencing the penetration of emerging technologies into social practices.

4.2. Needs, uses and practices

Fischer notes that "the consequences of a technology are, initially and most simply, the ends that users seek" (Fischer, 1992: 18). However, people tend to seek multiple ends at the same time, and often there is a certain level of conflict between them. The need for

privacy, for example, can be in conflict with the need for independence, if the latter implies being constantly monitored. Barrett (2008) found in a U.S. survey of older adults that nearly 9 out of 10 people agreed with the statement "if I need help to stay in my own home I would be willing to give up some of my privacy to do that". Needs will vary across individual older people. Needs between the cared for and carer may also be in conflict (Blythe et al., 2005). For example, carers may look to monitoring and tracking technologies as a means to reduce the frequency of visits to older people. Meanwhile, older people's wellbeing (and health) may derive in part from their desire for human contact and interaction that carers provide. There can be a mismatch between perceived and actual needs. Co-design (as referred to earlier) helps to provide reminders that people's own hierarchies of need may differ from those presumed by designers, as illustrated in the case of smart clothing and wearable technologies. Individual users can have an interest in how such technologies could help support their social participation while designers may be fixated on vital signs monitoring which users see of much less interest (see Skippon and Garwood (2011) for a related consideration of symbolic versus functional goals). One interviewee lamented the risk of technology being seen as principally about helping older people to *survive*. In his view quality of life comes from people having a sense of purpose, a meaning to their lives: "people want to feel useful, that means different things to different people, and what you can actually do and how you actually do it varies depending on your constraints" (Ageing Expert).

This centrality of human interaction was a key theme emerging from the interviews. While 'ageing in place' in one's own home may be seen as more desirable to moving to a residential care home this may very much depend upon the degree of human interaction both entail. If individuals' mobility outside of the home is increasingly limited then their reliance on episodes of external visits into the home (real or virtual) may be greater. This could be at odds with technologies that are seen by their carers as enabling more independence though less visits. As one interviewee put it succinctly, "sensors don't give you social interaction" (Ageing Expert). Hence although monitoring technologies may enable people to live in their own homes for longer, if they replace important social contacts of older people their quality of life may actually worsen.

Whether external 'visits' into the home are real or virtual is a moot point. On the one hand, easy-to-use video interaction with others to provide virtual contact may be important in terms of providing mental and/or physical stimulus which improves wellbeing. However, if this comes in place of real contact rather than as a supplement to it then social interaction overall may deteriorate in its quality and stimulation.

What becomes strongly apparent from the interviews is the need to extend beyond *functional thinking* (Geels and Smit, 2000). It is not enough to consider what technologies can do. There is a need to understand and address how they interface with the lifestyle needs and aspirations of older people.

4.3. Assistive technologies' potential consequences for travel

All interviewees were asked in what way they thought the behaviour resulting from using technologies may have an impact on mobility and travel. Traditionally in transport planning, households have been considered as the tripmaking unit—i.e. the originator of trips. However, one interviewee emphasised the distinction between the individual travelling to the healthcare and the healthcare coming to the individual. Travel surveys have tended to focus upon trips originating from (and returning to) the household rather than households as trip attractors. For healthcare coming into the home then associated levels of tripmaking have not been receiving the same attention. They are less monitored and hence their effects are more poorly understood. It

seems plausible that people living longer in their own homes generate more trips than people living in residential homes. 'Ageing in place' may therefore come at a greater cost to society in terms of the overall transport demands it imposes.

In addition, technologies to support the desire for social interaction may well perpetuate more social interaction that moves from the virtual to the physical and, through improved wellbeing from such interaction, enable yet more of the same over a longer period: "when people… can actually interact it actually increases the likelihood that they're going to physically get together, that increases the stimulus, the outward looking… Happy minds, healthy bodies, more travel" (Ageing Expert). Thus, not only does travel derive from the need to attend to individuals' health problems in terms of household generation or attraction of trips, but travel derives from healthy ageing that involves people leading full and active lives.

Such reasoning makes the assumption that as individuals grow older they necessarily *wish* to live outbound lives to such an extent. However, one interviewee pointed to two explanations for observed *decline* in activity in later life. One of these concerned constraints and impediments (with an implication that these might be overcome through technological or other means). The other concerned 'disengagement theory' (Tornstam, 1989), "people don't have the urge to go out as much, and it's more like, it's almost like it's a choice to stay at home, because of changes in preferences, beliefs, values and so on" (Transport Expert). This said, active ageing may delay an individual moving into the phase of not wishing to be as active (and thus perhaps engaging in less travel). Parkhurst et al. (2013) have recently examined the concept of a 'continuum of modes of connectivity' experienced as people age. In addition to corporeal (physical) and virtual mobility, they identify *potential* mobility and *imaginative* mobility. These different forms of mobility offer some means to positively respond in terms of wellbeing to any decline in physical mobility.

If housing technologies facilitate multigenerational households, reliance on public sector transport provided by social services may decline as the needs of older people are absorbed and catered for by the households in which they reside. Allied to this will be the technologies that can either obviate the need for a trip to a hospital or doctor's surgery through remote monitoring or could limit the tripmaking involved: "there is lots of talk now about whether you can use broadband so that people just visit their local doctor and be diagnosed there rather than having to go to a major hospital, so reducing trip lengths" (Transport Expert). The effects of such technology uses could be to free up older people's time. The question then becomes, how will this time be used? One use could be to make further (discretionary) trips that promote their social participation, sense of purpose and, ultimately, wellbeing. Thus travel may not be reduced overall but instead 'remade' in a way that contributes to quality of life and prolonged healthy ageing (thus extending, as noted earlier, the resulting travel demands). Similarly, for informal carers (family members and close friends), technology may reduce the (functional) need for as much travel directly associated with supporting an older person. However, such travel may itself have been suppressing other desired travel—a latent demand that is realised once time is freed up (see also Wiles, 2003).

Assistive technologies are likely to significantly influence travel patterns. However, specific insights into travel demand consequences are challenging to pinpoint. They are not necessarily intended, anticipated, direct or first order effects that emanate from the starting point of assistive technologies' take up. Travel consequences of living in later life will be affected by the residential form of living, the amount of care needed, the way care is provided and flexibilities and desires in relation to discretionary travel (see also Coughlin, 2009).

4.4. Accounting for assistive technologies' effects in travel demand analysis

All our transport experts saw the importance of accounting for the (indirect) effects of (non-transport) technologies on travel demand.

4.4.1. Should these effects matter?

One interviewee reasoned that analysis of route choice and (to a somewhat lesser extent) mode choice was largely related to matters within the transport domain; but "[o]nce you go back to the distribution of trips or the number of trips, it seems to be there that using the transport system with all its explanatory variables becomes less and less satisfactory" (Transport Expert). This interviewee provided a reminder that travel is principally a derived demand. It follows that assistive technologies that are influencing how older people meet their healthcare and social participation requirements must be significant for travel demand analysis. "[I]t always seemed to me a bit anomalous that, we think we can model travel demand with not looking at these other drivers that are affecting the sectors that actually generate the demand for movement… the fact that growth in mobility has stopped now, and we don't really understand why indicates that obviously our transport models are not predicting that" (Transport Expert). It was suggested by another transport expert that to avoid considering such other drivers may have major implications for the effectiveness of investment decisions. "[I]f you are not aware of those possibilities and developments then you will be surprised and big investments may become either more necessary than they might otherwise have been, or you may have made big investments that turn out to be a waste of money."

4.4.2. How well addressed are these effects?

Most interviewees acknowledged that there is not enough joined up thinking. There is a lack of integration between government departments, between the public and the private sector, between policy development and policy delivery, between academic disciplines and between academia and the public sector. Even where there have been attempts at integration such as that between land use and transport, there remain considerable doubts over our capacity to interpret. "[E]ven if you did have fairly reliable information on future land uses that doesn't necessarily help because for example if you were forecasting ten or twenty years ago shopping patterns in 30 years' time, even if you had very good forecasts on where supermarkets are going to be located in relation to residences, that wouldn't take account of internet shopping" (Transport Expert). This observation points to the fact that knowing *where* older people will be living will not provide us with a sufficient amount of information to assess their travel demand. For this we need to know *how* they will be living too: how much travel will be required to fulfil their needs and desires, who will be doing the travelling, when, and how?

Some experts did describe examples of where they had been able to bring possible negative unintended consequences of non-transport policies for transport onto the agenda during the policy formulation process. Nevertheless, a widely applied and recognised process of thinking through the possible unintended consequences of policies and developments for other domains appears to be lacking.

4.4.3. Why are these effects not well addressed?

Although the effects of (non-transport) technologies on social practices and in turn travel are complex to follow through, if they are potentially significant why are they not at least given greater consideration? One interviewee rather starkly offered some possible insights: "I do find it a very insular world, the world of transport, dominated by men, dominated by engineers and allegedly with quite a lot of networks within it which lead to insularity at best and corruption at worst… the current way in which transport institutions run attracts a certain type of personality. So people that like to have things fairly self-contained, and measured and so on and battened down I think are probably attracted to transport. I certainly seem to meet a lot of them of that kind of personality, very narrow. Very clever a lot of them you know but clever in the sense of being trainspotters if you like" (Transport Expert). This interviewee suggested that many of those in transport wish to see technical, scientific, contained and soluble problems within their domain.

Some of these sentiments were shared across interviewees. There was also a collective acknowledgement of the sheer complexity and difficulty involved in creating a better understanding of the interconnections between transport and other domains. "I think very few people are equipped with the tools, so both say the techniques and the software as well as the conceptual tools and the creativity to actually make sense of these enormous streams of data that you create, it is just too, it just becomes too complex. And that flies right into the face of the transport studies community, which I think is very much committed to a Cartesian reductionism, keep things simple, look for the basic laws. Focus on those" (Transport Expert).

Some interviewees referred to the uncertainty surrounding the matter of how big an issue it actually is to deal with this complexity. How relevant is it to understand the linkages between transport and other domains, and do the costs involved in increasing this knowledge weigh up against the benefits of doing so? The fact that many of these relations are "not always amenable to quantification" (Transport Expert), partly due to their complexity and partly due to a lack of available data, hamper our ability to provide an unambiguous answer. The current climate of funding cuts, in which "people are very busy dealing with what's already on their desk. Until someone comes along with some evidence and says, 'Do you realise that?' then attitudes will change" (Transport Expert) does not help.

In general, the strong emphasis on trend extrapolation and modelling in current examination of transport in the future was judged to have serious limitations because of a tendency to assume stability. One transport expert pointed towards the example of wheelchair access on trains and the fact that national standards are not recognising the changing size of people and their wheelchairs. Another transport expert built on this to suggest that we are not even questioning whether medical developments may mean in the future that wheelchairs are not even needed for mobility with the prospect of bionic limbs. This example points to unavoidable uncertainty in one respect (wheelchairs versus bionic limbs) and instability that can be accounted for (more) predictably on the other (the changing size of people). Furthermore, one of the transport experts sees the inability of many transport experts to appreciate the importance of framing a technological development. In other words a failure to see it beyond its narrow intended domain-specific purpose and appreciate how it will interact with and be taken up within social practices as it becomes embedded or 'domesticated'. Without such framing, complex though this itself is, the prospect of making anything resembling sensible predictions is arguably limited. This interviewee was frustrated by what was seen as the trap of incremental thinking—trend extrapolation that is not geared towards grappling with the potential for step changes driven by environmental imperatives if not societal desires.

Finally, one transport expert also pointed to the overriding 'transport is here to serve' mentality as a root cause of failure to account for non-transport technologies and developments in other

sectors when considering travel demand analysis. Transport is seen to be responsive to the needs of society – the demands society places upon it – rather than being something that should be considered in conjunction with the ongoing shaping of society —master planning of land use has tended to be *followed by* transport planning for example.

4.4.4. Alternative approaches for addressing non-transport technologies in travel demand

Given a sense of the limitations of trend extrapolation, interviewees gave attention to the prospects of closer monitoring of current behaviours and practices as a means of yielding more or complementary insight into future trajectories. It can be argued that there are indeed 'tastes' of the future available in small pockets in the present. The challenge, however, is still to be able to determine which such pockets change in scale to become dominant forces in future. A further challenge is that looking at the present and present day older people cannot easily account for how older people themselves may change in successive cohorts of ageing. This concerns potentially different attitudes, beliefs and values; different norms of social practice; and different affordances of mental and physical health and of mobility. One interviewee referred to the different 'heart rates' of development which made any predictions difficult. For instance while technology itself may evolve rapidly other forms of development, social and institutional, may be much slower to change: "I mean law still takes five years to produce… Accounting systems still take a year, large scale civil engineering still takes three to five years to deliver something significant" (Transport Expert).

One transport expert suggested that more attention might be paid to small practical pilot or 'performance' studies (perhaps in conjunction with ethnographic methods). These might gain a richer understanding into how people respond to technological possibilities as they seek to combine these with their lifestyle practices and underlying needs. Another transport expert favoured greater attention being paid to retail and consumption patterns to yield evidence of trends with implications for transport. In addition they suggested closer examination was needed of projects that failed to launch because they ignored human aspects of technologies. In other words there is a need to learn from the past in order to appreciate how the future may unfold beyond the limited gaze of 'Cartesian reductionism' (see Geels and Smit, 2000).

Overall, there was general agreement that the inherently complex and dynamic nature of transport and non-transport technological developments and behaviours requires new methods in order to be better understood. Close monitoring of such developments and especially behaviour was seen to be essential, but still leaves the question of how one determines what to monitor.

4.4.5. Demise of the transport profession as we know it

Hitherto the discussion has mainly concerned how academics and policy makers can improve the integration between transport and other domains. This has largely neglected what might prove to be the elephant in the room—the (non-transport) private sector. One interviewee suggested that big corporations from the non-transport sectors could move into the transport sector. They might see the value to their own businesses of running the transport systems such that they can monitor patterns of movement allied to other (consumption) behaviours. "[A]ctually I think that the transport industry will be left behind and that other industries will take it over and transport professions will be downgraded, left at middle management level and just won't be part of these new developments probably" (Transport Expert). In other words, much of what we consider today to be the preserve of the transport profession may be subsumed by the roles performed by players in other sectors (see also Stoner, 2011). Whether and how social practice and wellbeing would co-develop (or not) alongside commercial drivers in the shaping of the future and the role therein of Government would remain to be seen.

5. Conclusions

The thesis behind our paper is that technologies shape social practices and social practices shape travel (and vice versa). It follows that in order to understand how the patterning of travel is continuing to evolve over time it is necessary to understand how social practices are being influenced by technologies. Through the twelve interviews we have explored this with a particular focus on living in later life—a matter pertinent to societies that are ageing. This examination has underscored that anticipated changes in activity and travel patterns related to the adoption of assistive technologies are fraught with uncertainty. There are many factors at work that are conspiring to influence not only where older people live but how they live. A number of different 'rhythms' of change are at work with varying tempos. Successive generations of older people will enter later life with different life histories, experiences, values and norms. Technologies are evolving rapidly (increasingly so) such that the art of the possible of today will be overshadowed by that of tomorrow. Mobility affordances face change in relation to energy supply, economic conditions and dexterities in later life. Social behaviours are evolving in terms of the life roles of older people and their relationships and interactions with other generations of family and friends. Furthermore, this is all taking place within and influenced by varying spatial contexts. The needs of older people living in rural areas differ from those in urban areas and so do technologies' abilities to meet these needs (Dye et al., 2010). Even within urban areas the specific spatial context influences older people's ability to cope with the challenges they face (Klinenberg, 2002). Taken together, these constitute a myriad of factors (known and unknown) that are changing and interacting in unpredictable ways to create a multitude of permutations of cause and effect. At the level of individuals we may be able to make some sense of this in terms of studying present day behaviours in detail as suggested by our interviewees. However, projecting this forward and scaling it up to determine the consequences for society as a whole would appear to defy the employment of reductionist approaches of analysis.

According to the collective view of our interviewees, we are far from having a comprehensive grasp of the implications of living in later life for travel demand and patterns of travel. This applies to the present as well as to the future. Further still our mindsets and the 'tools of the trade' that have been central to analysing transport developments may mean that better understanding eludes our grasp, unless we open up to a wider set of approaches. One such approach to further examine the potential implications for living in later life and travel demand in a structured manner would be the use of scenario planning. This could help stimulate and inform policy debate in this area. Scenario planning is distinguished from other techniques for looking to the future and is seen as a technique better suited to dealing with "high uncertainty and complexity" (Schoemaker, 1991). Indeed, "[i]n the present era characterized by uncertainty, innovation and change, increasing emphasis is being placed on the use of scenario planning techniques" (Amer et al., 2013). While prediction and forecasting tend to mask uncertainty through assumptions, scenario planning embraces and exposes uncertainty. Scenario planning aims to highlight the multiplicity of different futures that could unfold dependent upon the nature and interaction of a large number of drivers for change. It is helpfully summarised as follows (Government Office for Science, 2009, pp. 5):

Scenarios are stories (or narratives) set in the future, which describe how the world might look in, say, 2015 or 2050. They explore how the world would change if certain trends were to strengthen or diminish, or various events were to occur. Normally a set of scenarios are developed (between two and five) representing different possible futures, associated with different trends and events. These scenarios are then used to review or test a range of plans and policy options: the conclusion generally being that different plans are likely to work better in different scenarios. Alternatively scenarios can be used to stimulate the development of new policies, or as the basis for a strategic vision. They are also a useful means of identifying 'early warning' indicators that signal a shift towards a certain kind of future.

We would suggest a particular course of action would be to undertake a scenario planning exercise that employs two axes of uncertainty to create a 'double uncertainty matrix'—in other words four divergent scenarios of possible futures. The two axes would reflect uncertainty in: (i) the extent to which assistive technologies will feature in and support living in later life and, (ii) the extent to which the state would be able to provide care for older people. This approach would enable an exploration of different forms of where and how older people will be living in the future. In turn it becomes possible to better appreciate the aspects of travel demand that would then require further examination. This might then present the opportunity to determine appropriate present-day policy response that is robust to the uncertainties ahead.

We close this paper through an analogy with the monitoring and tracking systems for older people discussed earlier. We call for the need for transport planning and policymaking to pay more attention to 'monitoring vital signs' of society. We should ensure we have sensors in place but also that we are thinking through how to develop appropriate response systems to react to the signs of social and technological change. We look to scenario planning as part of the approach to assisting the transport profession in its later life.

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