

RESEARCH ARTICLE

Technology assessment in the mobility sector: What can we learn from social network analysis?

Maïke Puhe^{*1} , Torsten Fleischer¹ , Jens Schippl¹ 

Abstract · Many experts assume that increasing automation will lead to far-reaching changes in the mobility system. The pace and direction of this transition are a matter of great social interest. Therefore, the inclusion of citizens' perspectives is called for. However, similar as with other research approaches in technology assessment, there are two major challenges: the self-selection bias of such formats and the fact that automated driving cannot yet be experienced in the reality of people's lives. To tackle these challenges, we present a novel two-step research approach in this article. In the first step, a social network analysis is used to examine how people organize their everyday lives and the extent to which the mobility transition will affect them as a result. In the second step, representatives of different everyday configurations discuss the advantages and disadvantages of the transformation.

Technikfolgenabschätzung im Mobilitätssektor: Was können wir von der sozialen Netzwerkanalyse lernen?

Zusammenfassung · Viele Experten gehen davon aus, dass die zunehmende Automatisierung zu tiefgreifenden Veränderungen im Mobilitätssystem führen wird. Das Tempo und die Richtung dieses Wandels sind von großem gesellschaftlichem Interesse. Daher wird die Einbindung von Bürgerperspektiven gefordert. Wie auch bei anderen Forschungsansätzen in der Technikfolgenabschätzung gibt es dabei jedoch zwei große Herausforderungen: die Verzerrung entsprechender Formate durch Selbstselektion und die Tatsache, dass automatisiertes Fahren noch nicht in der Lebensrealität der Menschen erfahrbar ist. Um diese Herausforderungen anzugehen, stellen wir in diesem Artikel einen zweistufigen Ansatz vor. Im ersten Schritt wird mithilfe einer sozialen Netzwerkanalyse

untersucht, wie Menschen ihren Alltag organisieren und inwieweit die Mobilitätswende sie deshalb treffen wird. In einem zweiten Schritt diskutieren Repräsentanten unterschiedlicher Alltagskonfigurationen über die Vor- und Nachteile der Transformation.

Keywords · autonomous driving, mobility transition, social network analysis, participation

Introduction

Many experts expect automation to advance rapidly in the mobility sector and associate this with great transformative potential. In contrast to electric mobility, in which essentially an old technology is replaced by a new one, many expect automated vehicles (AVs) to initiate new or at least more efficient services that could lead to changes in mobility or even land-use patterns. For example, it could become more attractive to live in rural areas if travel time in one's own automated car or in a low-cost robotaxi or shuttle can be used to relax or work. This way, AVs could induce very far-reaching changes that are of great social interest. This means that society also has an interest in influencing technological development to avoid a development that might lead to suboptimal or non-sustainable dynamics.

Against this background, the question at the centre of this article is how societal views and perspectives – regarding a technology that does not yet exist – can be incorporated into participatory technology development. Firstly, it is important to understand the extent to which different forms of AVs could fit with everyday lives and peoples' mobility needs. This is crucial for anticipating the potential future impacts of AVs. Besides technical design and policy interventions, the stability and changeability of mobility patterns will have a decisive influence on the future direction of AV development; e.g. whether they will be used in public transport or in private ownership – or will they not be used at all? Accordingly, studies on autonomous driving suggest that the public reacts quite differently to the prospect of integrating autonomous driving into their daily lives (Fleischer

* Corresponding author: maïke.puhe@kit.edu

¹ Institute for Technology Assessment and Systems Analysis, Karlsruhe Institute of Technology, Karlsruhe, DE



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et al. 2022; Lindgren et al. 2021; Pudāne et al. 2019). Secondly, the strong societal relevance of AVs calls for involving citizens in the development of automated mobility at an early stage, when the future shape of the technology can still be influenced (Collingridge 1982). Empirical analysis shows that efforts to engage the public in governing processes have merely conceptualized the public as potential users rather than as citizens, who have their own visions and expectations on the issue. Visions of possible futures predominantly represent expert knowledge and market-driven views, while the perceptions and expectations of those potentially affected are largely obscured (Graf and Sonnberger 2020; Hopkins and Schwanen 2018; Stilgoe and Cohen 2021).

affect the development trajectories of the technology and its application patterns.

- Second, there is the aforementioned 'selection bias' when representing different societal groups in participation or research. It is important to cover a broad range of social realities to explore who are potential winners and losers in the context of a new technology, not only in terms of economic gains and losses but also in terms of accessibility, social participation, and/or reputation.

In this paper, we present and discuss a research methodology that attempts to address and hopefully mitigate both of these challenges in the context of autonomous driving.

The question at the centre of this article is how societal views and perspectives – regarding a technology that does not yet exist – can be incorporated into participatory technology development.

Empirical evidence points at a need for participation in the governance of innovations in general. The latest results of a regular study on technology acceptance in Germany found that two-thirds of Germans (66.8%) strongly agree or tend to agree with the statement "Citizens should be allowed to have a greater say in the future of controversial technologies" while a quarter (25.1%) are ambivalent and only 8.1% reject it (acatech et al. 2023, p. 6). Interestingly, the study indicates that older people and people with a low level of formal education and low household income demand greater participation than the average while at the same time being underrepresented in participation processes. It has been documented in research that, despite efforts to reduce this selection bias, it is mainly highly educated people who often share the same lifestyles, worldviews, and social environments who engage in participatory formats (Böhnke 2011; Bovens and Wille 2017; Felt and Fochler 2010; Stolle and Hooghe 2011). This suggests that citizens seem to have a strong demand to express their own, perhaps controversial or divergent, views.

This brings us to the core argument of this paper, which states that there is, on the one hand, a well-justifiable need for participatory approaches when it comes to technology such as AVs. On the other hand, however, such approaches have to deal with two central challenges that are well-known in TA and related disciplines:

- In the case of emerging technologies such as AVs, the first challenge is that the technologies to be discussed are usually not yet available and people have not yet had the opportunity to gain experience with them. Thus, a particular challenge is to achieve valid results that help to reasonably anticipate which aspects of people's daily lives will remain stable and

At this point, it should be noted that there are certainly very different framings and approaches to participation or participatory processes. There are numerous different forms of direct, dialog-oriented, or deliberative participation formats and almost as many definitions of what participation actually means (Remer 2020). The approach presented and discussed in this paper refers to a more research-oriented approach to citizen participation, in which involving citizens means systematically exploring the citizens' standpoints to improve knowledge for action.

How to assess the changeability of everyday life?

In mobility research, there is a longstanding tradition to analyze peoples' everyday lives through the concept of activity spaces (Golledge and Stimson 1999; Horton and Reynolds 1971). An activity space describes the geographical area where individuals perform their daily activities, usually comprising the individuals' home, workplace, and other locations visited within a specified time period. Typically, GPS tracking, mobile phone data, or travel diaries are used to reveal these locations. The concept allows to study how individuals or households schedule their activities, the extent to which these activities are geographically spread out, which modes and routes are taken, and how that differs between population groups. Among other purposes, information on peoples' activity spaces are typically used to calculate potentially accessible opportunities, such as bars, supermarkets or parks (Patterson and Farber 2015). However, what can't be revealed when only capturing people's whereabouts in time and space is that their activities are also socially embedded. The persistence of people's activities is also attached to the meanings, emotions, or social statuses associated with them. For example,

if someone chooses a particular supermarket, it may be because it is more accessible than others. In that case, offering that person a more accessible supermarket might lead to changes in that person's mobility patterns. At the same time, some population groups use shopping as a form of social distinction. For example, by buying food only from selected stores. Where food is bought is then not easily substitutable but a matter of social belonging (Puhe et al. 2020). Consequently, capturing information about what people do or potentially could do does not provide enough information about whether they would like to do it differently, or whether they would rather hold on to their routines, even if travel conditions changed.

Any approach to exploring unknown futures must be able to put respondents in a position to relate their perceptions and anticipated behaviours to their emotional, social and temporal context of everyday life.

A common approach to assess changeability in transport studies is stated choice surveys (Axhausen and Sammer 2001; Gkartzonikas and Gkritza 2019). Respondents are presented with hypothetical choice situations and asked to choose one of several travel options for this situation. The presented situations may or may not include innovations that do not yet exist in reality. These travel options are further characterized by different attributes, typically by travel time and travel costs. This allows researchers to sort individuals by their characteristics (e.g. income) and relate them to their likelihood of changing their behaviour if certain characteristics of the transport system change. However, from a methodological point of view, this approach is associated with difficulties, as the hypothetical situations may be quite different once the technology has become a reality. In particular, the limited choice of attributes, which are usually framed by the researchers and not the respondents themselves, can lead to systematic biases (Fifer et al. 2014). Additionally, stated choice surveys inform us about single-choice situations, but not about the minor and major changes to everyday life this could cause. In line with this Lindgren et al. (2021) argue that any approach to exploring unknown futures must be able to put respondents in a position to relate their perceptions and anticipated behaviours to their emotional, social and temporal context of everyday life.

Having this in mind, we developed a research design that combines both approaches: the idea that the configuration of everyday life is a good starting point to analyze stability and changeability. And the idea of confronting people with potential future situations and inspiring them to imagine how that would affect their day-to-day actions. To do so, we designed a research approach, comprising of a qualitative social network analysis

(SNA) to capture peoples' activities in their social context and efforts to put respondent in the position to imagine if and how different forms of autonomous driving would affect their configuration of everyday life.

Social network analysis – can we use it to explore people's mobility patterns?

SNA is an empirical research method particularly suited to studying patterns within the social relationships of actors. A social network refers to a set of social entities (e.g. individuals) and the relationships between them (Wasserman and Faust 1994). These relationships can take various forms, such as friendships

or family bonds, as well as exchange of resources or social positioning, to name just a few. SNA aims to describe and analyze these relationships with their specific meanings and implications for people's doings (Marin and Wellman 2011; Scott 2017).

In line with this, social-science based mobility research has shown that social relationships significantly influence mobility patterns. Whether it's visiting friends, attending business meetings, or shopping at a particular supermarket, travel is seen as a way and often a necessity for building and maintaining social relationships (Urry 2003, 2007). To explore the various connections people have with others, as well as with institutions or locations, we define a social network as a web of relationships formed by individual, corporate, and collective actors. This perspective includes not only other individuals, such as family members or friends, but also entities like supermarkets, hairdressers or sports clubs (Puhe 2023; Puhe et al. 2021).

Our initial approach includes two semi-structured face-to-face interviews and a mobility diary. The idea of the approach is that participants identify their social relationships during the first interview and explore how these relationships are apprehended and embedded in everyday life. Respondents are then asked to fill in a mobility diary for seven consecutive days. This step mainly serves as an instrument to put respondents in the position to reflect upon their mobility and everyday practices. The second interview, which takes place after the completion of the mobility diary, delves deeper into mobility aspects like mode or destination choices. It was during the second interview that we presented potential mobility futures, like robotaxis, minibuses or privately-owned AVs. The idea is to take real situations from the first interview and/or the mobility diary to discuss for what reasons AV-based mobility services might lead to changes in

mobility behaviour or not. This allowed the interviewees to use familiar everyday situations as a starting point to find their way into the new topic. Up till today, we have used this method in several research studies with slightly different focuses, totalling 90 interviews to date.

Can we use SNA to mitigate the 'ex-ante challenge'?

We have found that by starting with people's social relationships, we have enabled participants to explain how they configure their everyday lives and what is important to them. This has allowed them to envision how a hypothetical scenario like the availability of different AV services could impact their existing routines and consider the potential consequences. The basic idea of this approach is to bridge the gap between the abstract realms of a speculative scenario with the very tangible obligations, desires, and demands of everyday life. Central to this approach is to look at possible future socio-technical

initiated about how the technology should and could be designed and to what extent the technology or related services would meet their needs. An interview with an older lady brings this to the point:

"Sometimes, when I'm walking, like when I go shopping on foot, the nearest bus stop is too far away, right? I can imagine it would be useful if there were something like a dolmuş [shared minibus operating on a circular route] serving this area. There should be more benches around here then, where people could sit and wait. That, for example, would make sense to me." (e_f_WeiDam_10).

From our point of view, the approach of focusing on people's social relationships enabled participants to explain their daily routines and envision how hypothetical scenarios could impact these routines. This allows us to assess whether changes in ac-

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constellations from the perspective of everyday situations and not primarily from the perspective of as-yet-unknown technical possibilities.

Accordingly, starting point for this part of the interview are the social relations of which participants had reported about earlier. For example, a mother of little children working three days a week was asked whether she could imagine using an AV for her commute. She states:

"Then I would probably work even longer. I have a demanding job, you know. If I could really switch off and use the time for myself, that would be great. And also to prepare for the day in the morning and not arrive stressed because the morning was tight or everything at home was just about making sure everything worked." (p_f_WeiDam_8).

In contrast, an older man, retired and still very active, states he wouldn't need an AV in everyday life, but imagines that he could use it for his recurrent holiday journeys to France:

"The drive takes about twelve hours. If I could relax on the highway, let go of the steering wheel, and just look at the scenery—not even read, just look at the scenery—that would be an advantage, yes. But here in town, I prefer to drive myself." (e_m_WeiDam_4).

By putting respondents in the position to imagine how a technology could affect their everyday lives, a critical dialogue can be

tivity participation, mode and destination choices as well as the temporal organization of daily life are likely in response to potential changes in the mobility system. However, the lack of heterogeneity remains.

Can we address the selection-bias by disclosing people's social networks?

As outlined above, engaging people with different perspectives presents a significant challenge to participation formats. The most common approach to ensure a variety of perspectives are included is to create weighted samples, e.g. regarding gender or age. However, being a winner or loser of a socio-technical transformation is not solely determined by single socio-demographic characteristics but often by different obligations and practices in daily life (Huning 2014). Thus, inviting more women than men or more older people than younger people does not guarantee a greater diversity of perspectives. Such an approach runs the risk that mainly those who are interested in the topic or more open to change will participate.

Against this backdrop, organizing a balanced participation in terms of socio-demographics is necessary but insufficient if the aim is to explore how different services or technologies can or should be shaped to serve people's diverse demands.

Therefore, we argue that knowing more about the differences in what people do in everyday life is as crucial for understanding mobility needs as socio-demographics. In order to identify diverse configurations of everyday life, we propose to first use a quantitative method. This step has to be done before the

participation round. We are currently working on standardizing the social network analysis part by developing name generators to quantitatively capture people's social networks. This will involve generating a list of respondents' social relationships and asking questions about the implications of mobility, such as mode and destination choices, frequency, and regularity of interactions. We expect to discover prototypical network configurations, which can then be used as a basis for selecting participants for a participation format. We believe that this step is essential to uncover distinct realities beforehand that would not be apparent—or would only be seen at random—if we'd relied solely on socio-demographics. To overcome the selection-bias, it is of course important to ensure that the different types are sufficiently represented in the qualitative analysis. However, the survey at least gives us control over whether we were actually able to recruit them at all. We hope that a targeted invitation to certain people in the sample might help to convince them to take part in a discussion group or an in-depth interview study.

Conclusion

It is often difficult to explore how speculative scenarios, such as the introduction of autonomous driving, might affect or disrupt current practices or socio-technical constellations. In this paper, we propose a research methodology that aims to target and hopefully mitigate the self-selection bias as well as a bias we have termed the 'ex-ante challenge' when exploring citizen views and perspectives on socio-technical transitions. The ex-ante challenge refers to the problem that it is often challenging to explore people's perceptions towards an innovation that is not yet available. The proposed approach aims to build a bridge between speculative scenarios and real-life situations by putting the changeability of social relationships to people, institutions and places to the forefront. It is these relationships that make up everyday life. As such, they are a rich source for explaining the stability and changeability of people's activity spaces. Specifically, our approach takes social relationships as a starting point to enable citizens to consider how certain interventions or innovations would affect them and to what extent they would be willing to let that happen. What we have learned from applying the method in different research contexts is that it enables citizens to move from hypothetical considerations to concrete discussions about how the transition would affect their everyday routines, obligations, and social relationships. To also address the selection bias, we propose to include a quantitative survey as a first step in the research design to obtain a more generalizable view of how differently people configure their social networks. We expect to find people with prototypical network configurations, for example, some with a geographically dense social network as opposed to people with widely dispersed social networks. In terms of mobility transitions, such as those envisioned by autonomous driving, it should be fruitful to hear what these

different groups have to say about likely use cases or acceptance criteria.

The approach may initially appear time-consuming and expensive. However, the development of a standardized form holds the potential for efficient implementation in the long run. In light of the perceived investment, the resource requirements for its implementation should remain relatively modest when compared to the substantial investments often associated with the introduction of new technologies or infrastructural changes.

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**DR. MAIKE PUHE**

is part of the research group on mobility futures at the Institute for Technology Assessment and Systems Analysis (ITAS) at Karlsruhe Institute of Technology (KIT) since 2010. Her research interests focus on understanding the interrelatedness between technological innovations and social developments within the mobility system, in particular the potential of technologies to change established mobility patterns.

**TORSTEN FLEISCHER**

is a senior researcher in the research group 'Mobility Futures' at the Institute for Technology Assessment and Systems Analysis (ITAS), Karlsruhe Institute of Technology (KIT). He is particularly interested in the development of automated driving and its interactions with sociotechnical path-dependencies.

**JENS SCHIPPL**

is head of the research group 'Mobility Futures' at the Institute for Technology Assessment and Systems Analysis (ITAS), Karlsruhe Institute of Technology (KIT). Originally a physicist by training, he is now interested in the interdependences between societal and technological change in transportation and digitalization.