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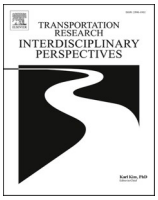

Understanding skepticism of smartphones in travel behavior research: A qualitative approach

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ABSTRACT

Travel behavior research is increasingly reliant on data collected from smartphones. However, recruitment is challenging in app-based travel surveys, which can cause data quality issues, such as non-response bias and erroneous trip rates. We aim to explain why it is challenging to get people to participate. This article is based on an analysis of transcriptions and notes from two qualitative studies, using risk, diffusion, and privacy theories. We have identified six themes in the data material and have developed a typology of reactions to smartphone apps. Perceived risk and digital technology interest may explain reactions to the use of smartphone tracking technology in travel behavior research. In the future, this typology can be used to improve our understanding of non-response in smartphone travel surveys and mitigate these.

Introduction

Travel behavior has been studied for decades, traditionally using travel surveys (TS) (Wang et al., 2018). It is important to choose the right tool for data collection because the data quality is affected by how satisfied the respondent is with the travel survey instrument (Roddis et al., 2019). Smartphone apps are a promising new platform for collecting travel survey data, with the potential to provide higher precision (Hong et al., 2021). Traditional travel surveys ask respondents to recall travel behavior from memory. On the other hand, smartphone apps, with tracking technology, remove this limitation. There are three main ways to utilize smartphones in travel behavior research: (1) analysis of cell tower data (Lee and Sener, 2020; Saxton, 2018), (2) using designated travel survey apps, e.g. Atlas II (Safi et al., 2015), TravelVu (Hubrich et al., 2020), MoveSmarter (Geurs et al., 2015), or MEILI (Prelipcean et al., 2018), and (3) extract data from other tracking apps. One app in the third category that has made its user data available for purchase and is popular among travel behavior researchers is *Strava* (Griffin and Jiao, 2015; Jestico et al., 2016; Raturi et al., 2021). Crowdsourcing data is gaining popularity because it is a relatively efficient, low-cost way to collect large amounts of data. If the identity of a smartphone user can be determined, travel data collected from the phone could be combined with external registers, increasing the potential for further data analysis. Using such aggregated data in travel behavior research, however, raises issues of privacy (Nunan and Di Domenico, 2017; Rubinstein, 2013) and representativity (Livingston et al., 2021; Romanillos et al., 2016).

It has been challenging to recruit respondents in travel surveys with smartphone apps (Saxton, 2018; Svaboe et al., 2021). The success of such solutions is determined by the extent to which people *want* to use them, and whether they do so correctly. Some research on the acceptance of smartphone data use by researchers exists, but it is not very extensive. Moreover, the studies that do exist show that many smartphone users are skeptical about strangers analyzing their data (Julsrud and Krogstad, 2018). Thus, if this type of data is to be used in research and planning, the process must adhere to the norms and expectations of the population one wishes to study. A breach of trust can negatively affect the public perception of companies and public institutions involved. Still, smartphone-based travel survey pilots (Cottrill et al., 2013; Svaboe et al., 2021) have shown that some respondents continue data logging after the requested data collection period, indicating that there is an interest in having a record of travel behavior. Therefore, the current paper aims to identify recruitment challenges, by studying the topic qualitatively. Travel behavior researchers are more likely to identify the best data collection tool in the survey design phase by identifying the challenges. The following research question is asked: *Why is recruitment challenging in app-based travel surveys?* To answer this, we develop a typology of reactions to new technology, using smartphone

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apps as a use-case.

Using theory on risk (Beck, 2009, 1999, 1992) diffusion (Rogers, 2002, 1995), and privacy (Francis, 2008; Rachels, 1975), we have analyzed transcriptions from focus groups and notes from personal interviews, and developed a typology of reactions to smartphone apps. We use the typology to answer the research question. We neither aim to condone nor glorify technology that tracks movement and the use of it in travel behavior research. Instead, we aim to improve the knowledge of human reactions to new digital tools. Insights will allow researchers to better design travel survey methodologies that respondents are happy to use, potentially reducing non-response. Such data collection tools would be valuable in transport planning, provided that a representative part of the population uses them and are willing to share their data.

Background

In this chapter, we present relevant research and results from studies on how respondents react to the use of tracking technology, i.e., research on the *respondent perspective* on smartphone tracking. Then, the theoretical framework for the analysis is presented.

Reactions to smartphones in travel behavior research

Julsrud and Krogstad (2018) studied public acceptance of using mobile phone tracking data in Oslo and Tallinn, citing significant skepticism amongst respondents in both cities, towards institutions or governments collecting and analyzing such data. More than half of the respondents in both cities worried their tracking data would be mishandled or get astray (Julsrud and Krogstad, 2018). Further, no immediate connection was found between risk perception and the extent to which respondents used or relied on their smartphones; the most active social media users and users of navigation services were just as worried about their privacy being violated as those who did not use such applications. The authors did, however, find that the acceptance of using tracking data depended on the purpose. They were skeptical towards business development, while prevention of terror and crime was the most accepted. About half of the respondents said it would be acceptable to use tracking data to improve the transport systems.

There have been attempts of implementing tracking solutions in large-scale travel surveys, with mixed results. In France, GPS and smartphones were used in travel survey pilots in connection with the national travel survey. According to Richard and Rabaud (2018), smartphone surveys have recruitment, data collection, and processing challenges. During a GPS-based travel survey in Adelaide, Australia, focus group interviews were conducted (Swann and Stopher, 2008). Practical challenges were identified (e.g., low battery life, "clunky" device design, interface problems), but the authors argued that the GPS devices reduce respondent burden. Furthermore, some participants wanted to contribute and receive more from the project (e.g. provide feedback about data collection and context for their data). In Sweden, pilots with apps and cell tower data were conducted during the project *New solutions for future travel surveys* (Saxton, 2018). The project group concluded that even though the technology is promising, response rates are too low for use in national travel surveys. The Netherlands uses smartphones for an ongoing mobility panel (Thomas et al., 2018). In the USA, there are examples of smartphone household travel surveys (Flake et al., 2017; Lynch et al., 2019). In Singapore, a smartphone pilot was conducted with a subsample (1000 persons) in the Singaporean Household Interview Travel Survey (Cottrill et al., 2013). The authors concluded that recruitment was more challenging, and completion rates were lower in the smartphone sample. Furthermore, the travel behavior and demographics were fundamentally different between smartphone participants and online/call center participants.

Many popular apps exist that track movement using similar technology as travel survey apps. Garrett et al. (2021) studied the public acceptability of smartphone tracking and COVID-19 tracking apps in Australia. They identified that the main reasons for *not* using a COVID-19 tracking app were data security (privacy concerns, concerns about normalizing tracking, lacking trust in the government) and functionality (e.g., battery drain). Compared to users, non-users were to a larger extent misinformed about the technology. At the same time, more than 50 percent of respondents reported government policy as the main reason for having downloaded the app. VonHoltz et al. (2015) studied the use of smartphone health apps, finding that among app users in their sample, more information was shared willingly in their social networks than was shared with the health app providers (VonHoltz et al., 2015).

A 'digital divide' among certain population groups can cause challenges with an app solution (Cronley et al., 2023). Seifert et al. (2021) found that older adults may not utilize information and communication technologies (i.e. smartphones, tablets, high-speed internet services, etc.) to their fullest. This is because they do not use the internet due to lacking skills, not having internet access, or cannot afford it. Furthermore, Reddick et al. (2020) found that people living in rural areas or low-income households also can experience low connectivity, which is crucial in app-based solutions based on real-time data collection. According to Milne and Watling (2019), mobile phone (and thus app) users usually are younger, and digital technology use varies greatly between individuals. Thus, it is necessary to consider how to deal with populations less likely to use smartphones, such as elders, those with little economic/technological access to mobile phones, and minority community members (Lee and Sener, 2020).

Theoretical framework

We use risk, diffusion, and privacy theories to answer the research question. When studying the connection between the perceived risk of a negative outcome and digital technology use, we will use Ulrich Beck's theory of 'risk society' (1999, 1992). This theory can be transferred to the smartphone app context because it explains people's fear of future negative outcomes (e.g., personal information stored being hacked, leaked, sold, or misused) using the concept of *risk*. According to Sørensen (2018), risk society theory is a useful analytical tool when studying conflicts that emerge between laypeople, scientific experts, and authorities concerning new technologies; it provides a framework of how consumers can be skeptical about a new product, which can appear irrational from the authorities or science perspective, but is perfectly rational from the lay perspective. Beck's theoretical framework has e.g. been used to study youth media non-participation (Chu, 2020), phishing (Okpa et al., 2020), and autonomous vehicle malware (Vassallo and Manaugh, 2018).

We use diffusion theory to explain how knowledge and interest in digital technology can affect participation. Diffusion theory (DT) (Rogers, 2002, 1995) is a process that describes how new technology spreads from innovators to consumers through stages. This diffusion process may also be applied to app-based travel surveys. This is because diffusion theory is useful when studying the adoption of new technologies (Kasilingam, 2020; Sriwannawit and Sandström, 2015). Diffusion theory has e.g., been used to study smartphone chatbots for shopping (Kasilingam, 2020), chatbots on bank websites (Hari et al., 2022), digital low-carbon innovations (Wilson et al., 2022), smartphone use (Kim et al., 2014), smart home technologies (Vrain and Wilson, 2021), and mobile banking apps (Tran and Corner, 2016).

Regarding varying reactions to the request to share data on movement, we use theory on privacy from psychology. James Rachels (1975) devised a general theory on why privacy is important, explaining why people can be hesitant to share even mundane personal information (Mooradian, 2009).

Risk society

According to Beck (1999, 1992), *risk* is the anticipation of a catastrophe, the nature of which has changed in the modern age, i.e., after WWII. Old risks, e.g., earthquakes and famine were natural disasters

external to human control. Modern risks are products of human-made scientific and societal changes, such as climate change, terror attacks, inflation, and the restriction of civil liberties (Beck, 2009). Modern risks are invisible and not tangible, concern everyone and it is impossible to ignore them (Joas and Knöbl, 2009). For example, we cannot see climate change as this is a slow, gradual phenomenon. However, there is a possibility of a catastrophic event somewhere in the future due to climate change. Further, in a risk society, choices are made based on a potential future rather than on past experiences.

In summary, risks are causal interpretations of potentially horrible future outcomes due to modern technology and societal development. Furthermore, not everyone perceives something as a risk (e.g., not everyone fears climate change, or their data being hacked). Thus, while some believe that the use of a particular technology represents a source of risk, others do not. If someone experiences risk as omnipresent, they have three potential reactions (Beck, 2009): denial, apathy, or transformation.

Science and technology cause modern risks but are also tools to understand and prevent them (Beck, 1992). Due to the increasing complexity of modern risks, the average person only perceives future menaces such as global warming because of scientific knowledge and discovery. As a result, people have to personally decide whether to trust or reject scientists' statements (Joas and Knöbl, 2009). Legal and scientific professionals and the mass media are central in defining the risks, and communicating them to the general public (Beck, 1992; Cottle, 1998). Since modern risks are imperceptible and based on personal interpretation, shifting narratives may cause people's interpretations of them to become changed, dramatized, or minimized (Beck, 1992). Without the mass media's visualization of risks, risks are nothing, because they cannot be anticipated (Beck, 2009).

Manufactured uncertainties are publicly manufactured risks, which are incalculable, uncontrollable, created by society, collectively imposed, and individually unavoidable (Beck, 2009). The public dramatization of manufactured uncertainties often affects the most innovative branches of science because the pace of development is so fast that it exceeds society's imagination. This can result in fears of an inexistent future, which is difficult to rebut for scientists (since it has not happened yet), and can threaten freedom of research.

Diffusion theory

According to Rogers (2002, 1995), (1) an innovation (idea, practice, object), (2) is communicated through channels (e.g., mass media and social networks), (3) over time (4) to members of a social system. The extent to which an innovation is successful depends on the (a) relative advantage (is it better than the alternatives?), (b) compatibility (is it consistent with existing values, past experiences, and current needs?), (c) complexity (is it difficult to use?), (d) trialability (can it be experimented on?), and (e) observability (are the results visible to others?). Governments, communities, organizations, or corporations can use different tools to spur or stifle adoption, thus affecting an innovation's success (Rogers, 1995). Governments can e.g., impose mandates, award monetary incentives or deterrents such as tax credits, to influence the adoption of innovations. Similarly, corporations can advertise or adjust pricing. The *rate of adoption* is the relative time it takes for an innovation to be adopted by a social group.

Interpersonal relationships are more important than mass media in influencing attitudes toward an innovation (Rogers, 2002, 1995). According to DT, fewer people evaluate an innovation based on scientific research, but instead evaluate an innovation based on subjective evaluations of others who have already adopted the innovation. The *innovation-decision process* is the process where an individual goes from (1) having knowledge of an innovation, (2) forming an *attitude* about it, (3) deciding whether to reject or adopt it, (4) *implementation* (5) *confirmation* of decision (i.e. spreading the word) (Rogers, 2002, 1995). Rogers (2002, 1995) defined *innovativeness* as the speed with which an individual adopts any given innovation. Rogers (2002) categorized people into five groups based on innovativeness: (1) *innovators* (the first group to adopt an innovation), (2) *early adopters* (the second group to adopt an innovation—they have the highest degree of opinion leadership in most social systems, i.e. potential adopters look to this group for advice and information), (3) *early majority,* (4) *late majority,* and (5) *laggards* (the last group to adopt an innovation—they will only accept an idea when they are surrounded by peers who have adopted and are satisfied with it). The relative proportion of each group is illustrated in Fig. 1.

Privacy

According to Rachels (1975), the need for privacy on any particular issue depends on your ties (i.e. the type of relationship) with the individual you are considering sharing your information. Rachels discusses the importance of an individual having control of the information, and access to personal space. "Sensitive information" is not universal, meaning that what is sensitive for one person may not be sensitive for others (Francis, 2008). Some may consider for instance their age to be sensitive information, while others may not.

Methodology

This chapter details the methodology used for the paper, including typology development, data analysis approach, the coding process, use of probes, privacy, and anonymization. Lastly, some potential limitations are presented. We use data material from two qualitative studies, one using focus groups (FG) and one using personal interviews (PI). We combine the data material because the FG inspired the data collection of the PIs: The focus groups were conducted before a student travel survey pilot using a smartphone app (Svaboe et al., 2021). During FGs, we identified some interesting components concerning fear of tracking technology (i.e. risk) and interest in the digital technology itself, which could affect participation (i.e. new technology interest). However, we had not included all relevant questions and only included students in the FGs. Thus, we conducted PIs in 2021. This is why there is a time gap between data collections. Both data materials are used in the typology development.

Fig. 2 illustrates the process from data collection to typology development, similarities and differences between FG and PI in choice of population, recruitment strategy, probe (stimulus material), and data processing.

Typology development

A typology is a schematic compilation of different analytical categories, phenomena, or findings, often with multiple theoretical dimensions (Tjora, 2021). The purpose of developing the typology is to have a model to explain people's behavior when they are presented with new digital technology. Typologies are typically visualized using simple four-field models, allowing for a convenient presentation of empirical findings. The four-field model has two dimensions (at a time): horizontal and vertical. In this paper, we use these dimensions to visualize *value* dimensions connected to the use of new digital technology. The dimensions can be used to create a two-dimensional area with four different ideal types (Tjora, 2021).

Ideal types are conceptual tools developed by Max Weber as a result of a methodological discussion (Hekman, 1983). They are one-sided exaggerations meant to capture an essence, and are not mirrors of the real world (Ritzer and Stepinsky, 2014). This paper uses ideal types as they are described at the most basic level (Ritzer and Stepinsky, 2014, p. 119): "concept constructed (…) to capture the essential features of some social phenomenon". The social phenomenon herein is the reaction to new technology. The ideal types are useful to explain the complexity of respondent reactions in a simpler, more synthesized way, making their reactions easier to understand. The prevalence of responses is not crucial to the analysis presented. Thus, there is no discussion of proportions or frequency of the different reactions.

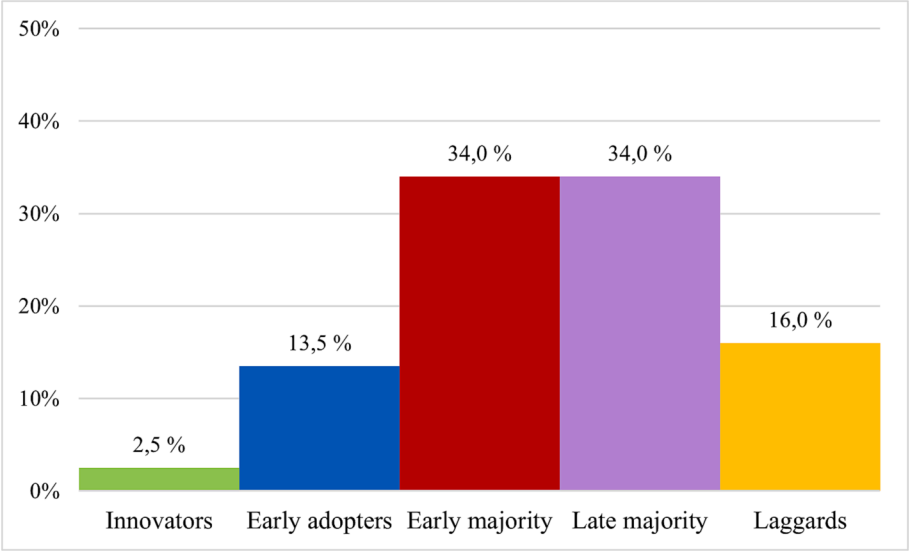

Fig. 1. Adoption of innovation (based on Rogers, 2002).

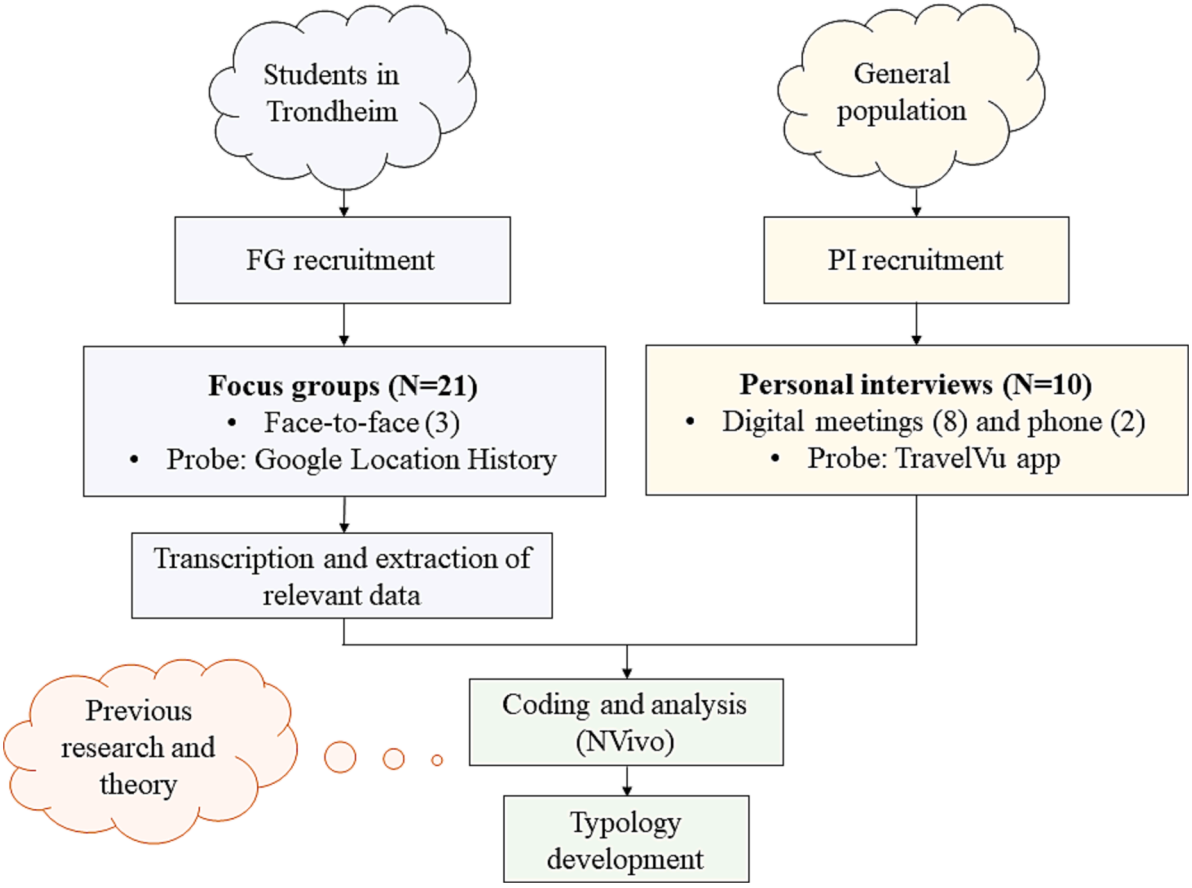

Fig. 2. Illustration of the process.

Data material

The research is based on parts of transcriptions from three focus group interviews in January 2017 and notes from ten personal interviews in May-July 2021. These data sources are described in more detail in the following two subchapters. Both FG and PI used non-random convenience sampling (Ringdal, 2018) and were semi-structured (Tjora, 2021), with recruitment from social media (information about the study was posted online) and personal networks (friends, colleagues, acquaintances, etc. recruiting on behalf of the interviewer, i.e. snowballing). FG recruitment also happened in lectures at NTNU.

Focus groups

The focus groups consisted of university students that had studied for at least one semester. Two groups had eight informants, while the third group had five. The interviews lasted 60–120 min, and audio was recorded, which was subsequently transcribed. In a portion of these interviews (approximately ¼), the possibility of using new digital technology in travel behavior research, privacy, and the use of tracking data was discussed. Transcriptions from these discussions were extracted from the data material and coded. Informants originated from different geographical places in Norway but lived in Trondheim at the time of the interview. The informants studied at different campuses, thus having different academic backgrounds.

Personal interviews

The personal interviews lasted 30–74 min. Due to COVID-19 restrictions, interviews were conducted as digital meetings (eight interviews), and over the telephone (two interviews). Informants were recruited under the following criteria: (1) to avoid bias, informants could not work within the transportation research field or at universities, (2) they were to be at least 30 years old to ensure that they had sufficient life experience and probability of having responded to a survey of some sort), (3) they needed to own a smartphone, and (4) they were not students (this group had already been studied in the FG).

After 4–5 interviews, the same stories and opinions started to repeat, and fewer and fewer new elements emerged. Interviewing was discontinued when no new information emerged, i.e., at the saturation point (Tjora, 2021). Thus, ten interviews are seen as sufficient. The informants, five men, and five women lived in different geographical places in Norway and were 30–81 years old. A description of the informants is presented in Table 1.

Thematic analysis

The data material was thematically analyzed at a semantic level (Braun and Clarke, 2006), i.e. combining codes to identify a common *theme,* where the themes were identified based on the explicit responses of the interviewees regarding the topic. A theme is a pattern that captures something important about the data in the context of the research question (Braun and Clarke, 2006). Based on previous research (Julsrud and Krogstad, 2018; Svaboe et al., 2021; VonHoltz et al., 2015), the researchers knew that the data material would include, e.g., new digital technology interest and risk as salient components, and that there would be differing opinions regarding smartphone use. These aspects were therefore used in typology development prior to coding.

The thematic analysis involved data material coding in NVivo, each with its distinctive meaning. Subsequently, a second round of analysis was done to remove irrelevant codes, combine overlapping codes and identify themes. The main value dimensions were structured as parent codes during this part of the analysis, and themes were created as child codes. For example, *fear of risk* was a parent code, and statements concerning risk were ordered as underlying child codes. Finally, child codes were sorted into six main themes, which are used to answer the research question.

Table 1
Description of informants.

Informant	Occupation	Age group	Gender
1	Coordinator	40–49	Male
2	Pensioner	80 +	Male
3	Musician	40–49	Male
4	Executive	60–69	Male
5	Bioengineer	30–39	Female
6	Administrative leader	60–69	Male
7	CEO	30–39	Female
8	Kindergarten teacher	30–39	Female
9	Principal	60–69	Female
10	Teacher	50–59	Female

Probes

Probes (stimulus materials) were used in both the focus groups and the personal interviews to get them to react to smartphone technology that tracks movement. The FG informants were given a presentation of the features of Google Location History (GLH). GLH is the location history of the mobile device, which is collected when the phone is signed into a Google Account and Location History is enabled. This introduced the informants to the technology and facilitated discussions on how they perceived it and felt about using it for research purposes.

In the PIs, informants were presented with TravelVu, an app developed to collect travel survey data. We used TravelVu instead of GLH in the PIs because we wanted an example of an app specifically made for travel behavior research. TravelVu passively registers trips and activities based on smartphones' Wi-Fi, accelerometer, and GPS data. The user verifies and corrects the trips and activities. The algorithms learn from the corrections and suggest each user's most probable travel behavior, provided the app is used over time. These apps were presented to informants as examples of such technology, and not as endorsements of their use. Although the aim was to avoid informants feeling pressured into voicing approval about the use of such technology, the interviewer emphasized that they had no personal stakes in whether the informants gave positive or negative comments about using an app for data collection. The participants were informed that the purpose for their participation was to identify tools to improve travel survey data collection, and not to, e.g., develop an app. The interviewer also made it clear that there were no right or wrong answers.

Privacy and anonymization

All participants were informed that they could withdraw from the study at any time, without providing a reason. All informants were anonymized and given a pseudonym. In the personal interviews, a notetaker was used, and consent to participation was collected at the beginning of the interview. A recorder and a notetaker were used during the focus group interviews. All informants in the focus groups signed a notification form to document voluntary participation.

Limitations

Two personal interviews were conducted by telephone, hindering the use of visual probes when discussing the use of smartphone apps for data collection. These participants received the presentation without visual aids. It is not likely that this resulted in significant data loss. One informant (elderly) interviewed by telephone did not use apps, with smartphone use limited to texting and calling. The other informant who was interviewed by phone had a high knowledge of apps and smartphones and had no problem understanding the concept.

In the PIs, not all age groups were interviewed because we prioritized reaching a diverse group of adults.

Lastly, a time gap between the two data collections could affect public perceptions (e.g., share of people interested in participating in a smartphone TS). However, we focus on identifying underlying value dimensions, not proportions.

Analysis

After coding the data material, we identified six key themes:

- Smartphone use.
- The feeling of being monitored.
- Mass media affect perceptions of technology.
- Personal statistics are fun.
- Participation is tedious.

- Control of information.

In this chapter, we present each theme with examples from the data. Then, we use the themes to develop the typology of reactions to smartphone apps.

Smartphone use

Among other background inquiries, personal interviews opened with a question regarding the extent to which participants tended to have their phones with them throughout everyday activities. This question aimed to map the risk of potential smartphone TS participants leaving their smartphones behind, resulting in data loss. Although "everyone" has a smartphone and brings it with them "everywhere", statements from PIs reveal that they use them differently. One informant had implemented routines to reduce at-home smartphone use, putting them away in a designated place. Another informant had to put their phone away during work hours. However, all PI informants expressed one variation of "always" having their phones with them, unless they actively put them away.

Always
PI informant 10 on how often they have their phone with them
It is always available. The only time it leaves the body is when it is on the bedside table
PI informant 4 on how often they have their phone with them

Even though the PI informants bring their phones with them "everywhere", in a purely physical sense, this does not mean they would be inclined to participate in smartphone TSs. And even if they were, not all informants were proficient in app use in general, so they would not necessarily be able to correct or verify trips in an app, if required. Secondly, not all PI informants had GPS and mobile phone data activated continuously.

Not that often
PI informant 5 on the question of how often GPS and mobile phone data is activated
Almost daily
PI informant 6 on the question of how often GPS and mobile phone data is activated
GPS is rarely activated
Informant 9 on the question of how often GPS and mobile phone data is activated

For the informants who do not have the necessary settings on constantly, passive data collection would likely result in data loss.

Feeling of being monitored

After the probe presentation, immediate reactions differed between participants in focus groups and personal interviews. Some FG informants drew immediate parallels between the app presented, surveillance, and monitoring, and some used the term "Big Brother". Some FG participants had issues with GLH being part of Google. All FGs brought up the following paradox: Participants "recognize" that they are being monitored by "big tech", which sells information about their whereabouts, search history, and activities in which they decide to engage. At the same time, however, participants get wary when presented with smartphone TS apps. It is seemingly worse to willingly participate in a smartphone app survey than to passively accept "terms and conditions" without reading them because then they *understand exactly* what they give away in a TS. It appears as if there is a difference between monitoring "being done" without their knowledge by corporations and actively consenting to be registered.

So there is a little difference in the fact that I just have my phone and it (Google) knows where I have it, that's fine, but if I actually actively go in and say "yes, follow me where I go" then I think there is a difference between people, even though it may be much the same.
FG 1 participant reflecting on consent and tracking technology

Some informants said they would be more willing to use an app created by an institution they trusted. Other informants did not find it problematic to be tracked when presented with the idea of a smartphone app TS: "We are already being monitored everywhere, so why not? " Such informants were naturally more optimistic. To them, movement tracking did not feel like an invasion of privacy.

I don't see any problems with it (tracking) really because you are surely being monitored on so many apps
FG 1 participant reflecting on tracking movement for research purposes

In the PIs, a similar split was observed. Some informants expressed that an app that tracks movement gave negative associations, drawing parallels with surveillance, monitoring, and the concept of "Big Brother is watching you", expressing that collecting and sharing such information was problematic.

They get a "Big Brother feeling"
PI informant 5 after the presentation of the probe
Information about individuals is collected and distributed without us having a full understanding of its purpose and scope. A bit like "Big Brother sees you". I understand the benefits, but I also have concerns.
PI informant 9 after the presentation of the probe

Others, however, saw no problem with sharing smartphone tracking data.

Yes, of course, no problem at all
PI informant 1 on whether they would participate in a smartphone-based TS (after probe)
The app is harmless and doesn't collect sensitive information
Informant 4 on whether they would participate in a smartphone-based TS (after probe)

Personal statistics are fun

Some of the FG informants who were positive about the app were also excited by the possibility of receiving personal statistics on travel behavior.

Student A: seems a bit exciting then, and maybe a bit fun to join in just to try it out?
Student B: Yes, and just see for yourself, have I walked that far?
Student A: Yes
FG 3, two students reflecting after the probe was introduced
Student C: I think it would be exciting to get the results myself
Student D: but when you see your travel behavior and so on, and maybe see it in relation to others, or means of transportation in relation to each other… I think it would be interesting… then I think I could download it, and see how I use transportation and maybe in relation to myself or yes in relation to the different means of travel and in relation to others
Student F: like if you walk a lot more than the average or something then it makes you feel good
{group laughter}
FG 1, 3 students reflecting on using an app that tracks movement

The same enthusiasm was found in some PI participants: Possibilities for examining their travel behavior were seen as beneficial, much like an exercise app is (but with more functions, since it includes car, public transport, taxi, etc.).

It is nice to get an overview of your activity. The informant and their partner are trying to walk more, so getting an overview of walking was nice
PI informant 4 reacting to the probe
Technology is fun
PI informant 6 on the concept of tracking movement with an app

Some informants considered what type of statistics they would find interesting, e.g., CO_2 footprint and transport mode distribution.

Mass media affect perceptions of technology

Fears of surveillance were not connected solely with the technology. Some FG informants discussed how governments could potentially

"snoop" at sensitive information.

If you get curious… those at NAV[1] who have looked up friends and acquaintances without… but yes, searched on their history – they became cases because they were curious… and so are we

FG 3 participant on curiosity and data security

[1] Norwegian Labour and Welfare Organization.

Some FG informants discussed positive experiences with fitness and exercise apps. The PIs were conducted shortly after a media storm surrounding a COVID-19 tracking app, which might have affected the perceptions of tracking technology. After the probe was introduced in the PIs, many drew parallels between TravelVu and the Norwegian COVID-19 tracking app, *Smittestopp*. Smittestopp was promoted through a large P.R. campaign before release, aiming to maximize the number of downloads. Shortly after launch, however, Smittestopp was criticized for privacy violations, resulting in low usage, P.R. damage, and a subsequent re-launch of the app (Amnesty International, 2020; Fjeld, 2020; Tjoflot, 2021; Zondag and Wergeland, 2020). The perception of Smittestopp varied amongst PI informants. Some discussed the positives of having an app for contact tracing, using similar arguments as during the initial promotion of Smittestopp.

In the new world, apps seem to be the way to go. It seems to work

PI informant 5 reflecting on the increased use of apps in today's society

We have benefited a lot from this technology. So it gives us a lot of opportunities for quick and fast and good communication. And we use that infection tracking app, so that's smart.

PI informant 9 on the use of tracking technology

Others, on the other hand, discussed how the app violated privacy using the same arguments as critics in the media.

The informant stated that they did not download Smittestopp because it is healthy to be skeptical in today's society

PI informant 8 on Smittestopp

All PI informants discussed the positives (tracking COVID-19) and negatives (privacy concerns) of being monitored. Their comments largely reflected the media campaign and scandals from the media.

Participation is tedious

Some informants stated that participation in app-based TS surveys would demand too much of the user. Those who found it tedious could be categorized into two groups:

1. those who would have problems with participating due to a lack of knowledge about how apps work, e.g., those who do not use smartphones beyond texting and calling.

Without a presentation, participation would be difficult and confusing. Apps can't be too complicated. Editing (validating trips in the app) makes it more complicated.

PI informant 6 after the probe presentation

2. those who would not necessarily have a problem with using an app but did not find this approach interesting as presented. For them, participation would be an inconvenience or a bore. Therefore, participation would only be a "time thief". One FG participant found the act of just opening an app to be an exhausting undertaking.

…think the less active you must be… just downloading an app can be a barrier because, actually, I don't know if there are others who think like that, but I find it annoying when everything has to have its own app then, eh, it's a bit cumbersome unnecessary

FG 3 participant on the thought of using an app as a data collection tool

We are drowning in apps

PI informant 7 on using smartphones in research

The app sounded very comprehensive and easy to de-prioritize… by asking someone to participate, you are asking them to de-prioritize their own time.

PI informant 8 on participation in a smartphone-based TS

Control of information

Several FG and PI informants had as prerequisites for participation in smartphone travel surveys that the institution responsible for data collection was professional, recognizable, and provided documentation of proper data processing and storage.

The purpose of the survey must be clearly stated, and why it is relevant, is what we have talked a lot about then, and the purpose, and why the purpose is important … why should you know where I travel during the week? And what can you use this information for?

FG 3 participant on what information they would need before sharing information

I think it would be fine too as long as it's not a horrible commercial company that wants to use it for advertising and stuff like that… if it's for research and stuff like that then sure

FG 1 participant on whether they would share smartphone movement data

I think it depends on who's asking to get the data because not everyone is willing to share data on where you travel… but you need to know that it is confidential.

FG 2 participant on getting people to share GLH data

Important to have integrity, show that no one else will have access to the data and that it will only be used for research. Important that no one should be tracked, taken for anything (after data collection).

PI informant 1 on integrity and data safety

You must be clear about who is collecting. If it is for research purposes it is more straightforward, but if it is a commercial actor, it is less interesting to be involved.

PI informant 6 on data collector

It is important to ensure that data is processed securely.

PI informant 8 on data safety

Such information would ensure participants that no business, enterprise, or public institution would inappropriately or carelessly handle their personal data. In addition, providing such documentation would establish trust. *Trust* was cited by many as a prerequisite for voluntarily providing data. Any presence of doubt in the data collector or app provider is very powerful and would be disastrous for any TS. Since the immediate personal gain of TS participation is limited or nonexistent, willingness to participate plunges if any doubt concerning information safety materializes.

Value dimensions

Based on the coding, previous research, and theoretical framework, six themes were developed in the analysis. These are used to describe two value dimensions used in the typology: *fear of risk* and *technology interest*. Ulrich Beck's 'risk society' is used to develop the value dimension concerning *fear of risk* (Y-axis), and diffusion theory is used to develop the value dimension *technology interest* (X-axis).

Dimension 1: Fear of risk

The first dimension, *fear of risk*, is an emotional component regarding the concern that some negative future outcome will materialize from using the technology. E.g., companies and/or governments will violate participants' privacy and use the information inappropriately, carelessly, or otherwise leave the data susceptible to hacking. The feeling of risk does not necessarily relate to the technology directly, but the technology *mediates* the feeling. It is a *perceived risk* that is socially constructed. Actors that can affect the perceived risk are, e.g., mass media, social media, friends, family, and politicians.

This is based on the following themes: (1) *Feeling of being monitored*, (2) *Mass media affect perceptions of technology* and (3) *Control of information*.

Dimension 2: Technology interest

The second dimension, *technology interest*, has to do with general knowledge and interest in smartphone apps. Technology interest affects whether participation in a smartphone-based travel survey is perceived as tedious or not. Those with a low technology interest typically have limited to no knowledge of apps and thus do not use them unless they *must*. Those who have a high technology interest know more about apps and would find them easier to use, and perhaps even fun or useful.

It is based on the following themes: (1) *Smartphone use*, (2) *Personal*

statistics are fun and (3) *Participation is tedious*.

Typology of reactions to smartphone apps

Fig. 3 details a typology of reactions to the app-based TS technology, with two dimensions and four ideal types. The typology assumes that underlying value dimensions affect the probability of acceptance of the technology. The risk is perceived and personal. The possibility of the data being mishandled from an objective standpoint is irrelevant. The fear of risk is a fear of a potential future where participation has led to a negative outcome, and not necessarily a fear of what will happen during participation. For instance, a person can fear that the data collected in a TS will be sold, leaked, hacked, or used against the person in unforeseen ways in the future, without fearing the TS itself. The outcome is still that they will not participate in the TS.

Ideal types

The *Risk avoider* has no interest in the technology and has a high fear of risk. Thus, the *Risk avoider* is unlikely to participate in travel surveys *at all,* due to the perceived sensitivity such individuals harbor related to reporting their whereabouts. The combination of high fear of risk and low technology interest makes it unlikely that adoption of new technology will happen willingly.

The *Skeptic* is knowledgeable about smartphone apps but is very concerned about privacy and has fears of being monitored. As a result, the *Skeptic* is wary of their digital trail, and data sharing, and is unlikely to participate in smartphone app-based surveys.

The *Excluded* does not fear being monitored but is uninterested in using the technology, or is unable to do so, owing to a lack of necessary skills. When adapting new technology, the Excluded is not actively avoiding technology due to fear of risk and should thus be understood as more of a laggard.

The *Technology optimist* is highly skilled in using smartphone apps and does not worry about being monitored. Technology optimists would be categorized as innovators when it comes to adapting new technology. They would participate in smartphone app surveys out of sheer interest in the process and the resulting statistics.

Discussion

In this paper, we attempt to explain why recruitment is challenging in app-based travel surveys, by developing a typology of reactions to smartphone apps, based on two qualitative studies. The aim is to improve the current understanding of respondents' reactions to new technology. Six main themes were identified, which were used to describe two dimensions that explain reactions to the use of smartphone technology in travel behavior research. Many reactions to smartphone app travel surveys are explained by the two dimensions presented in this chapter: 1) *technology interest* and 2) *fear of risk*.

The typology reveals why recruiting respondents to a smartphone travel survey is so challenging: the Technology optimist is the only one that would willingly participate. In travel surveys using traditional methods, the Excluded would *at the very least* consider participation, while it is unlikely that the Skeptic and Risk avoider would participate in travel surveys irrespective of data collection method since most travel surveys ask about whereabouts and background information, which would presumably be considered too risky to share.

Still, using the theoretical framework in the paper, change in perception and adoption of technology is possible using e.g., social networks, assuming that the adopters can communicate the benefits of using the digital technology to the non-adopters. The fact that the Norwegian government's media campaign affected the tracking technology responses indicates that mass media can affect the perceptions of new technology. Further, smartphones can serve a purpose in TS data collection as an option for those who prefer it. For example, the interest in smartphone technology could make some people more interested in participating, and for these individuals, personal statistics could incentivize their participation. For some people, the app can be understood as both an interesting innovation, and as something that can provide immediate value, or a reward, such as personalized statistics on CO_2 emission and suggestions for reducing it. Alternatively, the app could provide information on how to reduce travel time or costs.

A possible explanation for the low response rates in smartphone-based TS is that we are currently in a period where *innovators* have adopted tracking apps, and some *early adopters* are beginning to use them. However, early adopters have yet to confirm the innovation. In other words, the widespread use of smartphone apps in large-scale travel

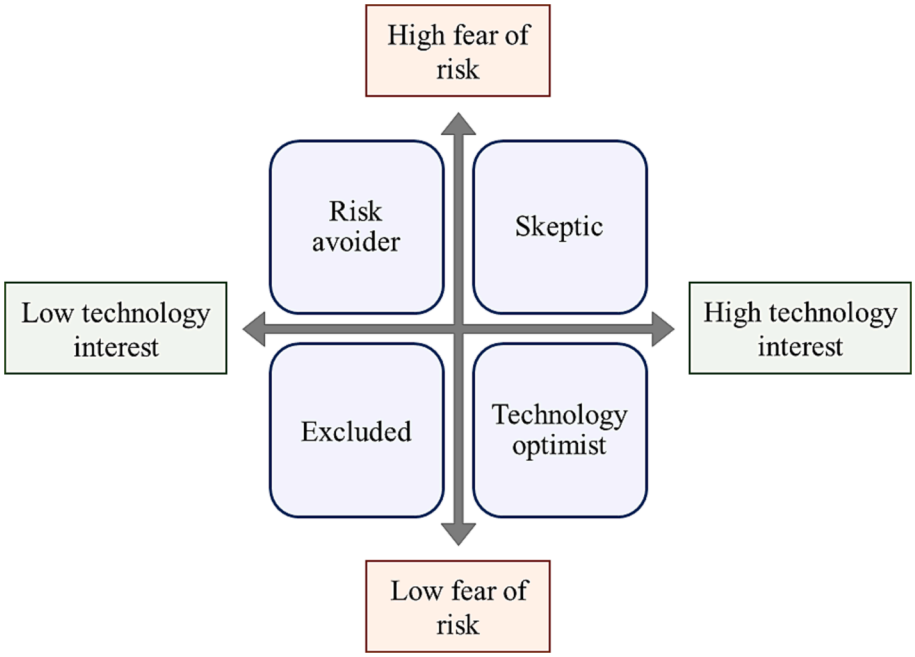

Fig. 3. Typology of reactions to smartphone apps.

surveys has not yet materialized, as the diffusion process is still in its early stages, assuming that the innovation will eventually be adopted.

Smartphone apps may facilitate data collection from some hard-to-reach groups that would not otherwise participate in travel surveys using other survey modes, such as telephone interviews, postal surveys, or face-to-face interviews. Thus, data collection using smartphones could presumably improve knowledge of travel behavior. However, exclusively relying on smartphone app data may not provide sufficient representativity in the sample. Rather, travel behavior researchers should utilize the strengths of new technology while being aware of its potential drawbacks, relying also on traditional methodologies.

People's perceptions of technology risk can affect the representativity of samples in travel surveys. E.g., if risk perception is related to age or technology interest, which may themselves be linked, smartphone travel surveys may under- or over-represent certain demographic groups. The elderly typically have less experience with smartphone use, which could lead to them being inadvertently excluded from a smartphone travel survey. This issue could be overcome using multiple data collection options, accounting for potential survey mode effects.

The results obtained from personal interviews may, to some extent, have been affected by the scandal of Smittestopp and pandemic-related lockdown restrictions. Still, these two potential issues highlighted some critical technology acceptance properties. First, people appear to be willing to download an app that tracks their movement, given the right circumstances (according to the Norwegian Institute of Public Health, Smittestopp was downloaded 1.3 million times (Norwegian Institute of Public Health (NIPH), 2022). Second, the public's trust in the government in Norway is high. Third, the sentiment conveyed about such an app through media is paramount to its success (many people downloaded Smittestopp at launch, despite its technical issues and the subsequent media storm). Fourth, the pandemic led to accelerated adoption of digital technology, exemplified through e.g., Teams, Zoom, and online shopping). This was perhaps a positive for this study, as undertaking qualitative interviews online would perhaps have been more problematic, had people not already started transitioning to digital platforms for pandemic-related reasons. Finally, digital recruitment also made the geographically diverse group of informants possible.

There are three potential challenges to the robustness of the typology: 1) the time gap between data collections (2017 and 2021), 2) the age difference between the FGs and PIs, and 3) not all age groups being included for both genders in the PIs. Regarding the first, when studying the reactions in both data sets, we found that the underlying value dimensions were present in both data materials. Regarding the second, we found both positive and negative reactions among the elder and younger informants in the PIs. Regarding the third, since we are not discussing proportions or sizes of groups, it should not pose a problem for identifying value dimensions; there were informants with high/low fear of risk and technology interest among the younger and older informants in the PIs, and the value dimensions were identified in both the FGs and PIs. Thus, we argue that the potential challenges of using both data materials are outweighed by the increased data richness of using both FGs and PIs.

Conclusion

This paper proposes a typology of reactions to smartphone apps for an improved understanding of people's reactions to smartphone apps for travel behavior research. The typology has two dimensions (*fear of risk* and *technology interest*) and four ideal types (*Skeptic, Risk avoider, Technology optimist, and Excluded*). The reaction to the use of smartphone technology depends to a large extent on their perceived risk of participation and their interest in the technology.

Implications

The proposed typology explains why recruitment is challenging when using smartphone tracking for travel survey data collection. If a person fears monitoring, they are unlikely to participate. Similarly, if the person has a low interest in app use, smartphone TS participation appears tedious, and the individual will not participate. In fact, the technology optimist is the only person "certain" to participate in smartphone app surveys.

Further, if transport researchers, or others involved in the undertaking, were to violate potential respondents' sense of privacy, this could tarnish the public's perception of even unrelated research that uses similar digital tools. Any such breach of trust would hinder researchers' current and future ability to obtain information about citizens' travel patterns due to the fear of risk. In some sense, transport researchers working on the potential use of smartphone data are responsible for the future of travel behavior research.

While this typology is developed with travel behavior research in mind, it can be used for studying other technologies and perceived risks. It can, for instance, be useful when studying the reactions to pandemic-related tracking apps and shed light on the extent to which the public accepts these. Further, the typology may explain why some individuals may be skeptical of 'new' technology, e.g., autonomous vehicles.

Recommendations

Future research could focus on the recruitment of respondents with different understandings of risk. It would also be valuable to study strategies for combining novel and traditional methods, making participating across age groups and technological interests easier to compensate for non-response. For example, giving a subsample of a travel survey the option to pick between multiple administration modes (CATI, CAWI, smartphone, face-to-face CAPI, etc.), to understand better which groupings tend to prefer each administration method. Combining data collection tools could mediate some non-response challenges because different groups might prefer different ways of reporting travel. However, a multi-mode solution demands that the data collector has a plan for correcting potential mode-effects.

The concept of gamification involves motivating and engaging users through tactics commonly found in computer games. It is gaining popularity across disciplines and could presumably also be used to increase positive sentiment toward travel surveys. While individuals with a high technology interest would presumably be affected most, gamification may even help the app be perceived as more "friendly" and approachable by the more skeptical groupings of the typology. Such strategies may, however, end up sabotaging their success, as highly gamified TS apps could potentially affect the travel behavior they're meant to record. Such solutions should be treated carefully. Nonetheless, such outcomes may also be beneficial: If gamification increases modal shares for soft modes through encouraging lower emissions or promoting sustainable travel, this could be seen as a net win.

Since there are variations within population segments, more qualitative interviews should be conducted to improve smartphone use knowledge. There is varied knowledge amongst e.g., elders regarding technology. Some younger generations may have the necessary knowledge, but still might be "tracking"-skeptics.

Improving all forms of digital data collection to reduce non-response, i.e., both smartphone apps and self-reporting computer interviews (e.g. CAWI) is important. Poorly designed interfaces can impede data collection since they reduce trust in the data collector and increase the respondent burden.

The next logical step with the typology of reactions to smartphone apps is to survey to quantitatively identify the proportion sizes of the reactions between population groups/segments. Travel survey designers could use this information to target data collection methodology, which could improve data quality.

CRediT authorship contribution statement

Gunnhild B.A. Svaboe: Conceptualization, Data curation, Formal

analysis, Methodology, Writing – original draft, Writing – review & editing, Visualization. **Arild Blekesaune:** Conceptualization, Writing – review & editing, Supervision. **Trude Tørset:** Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

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