Mobility in Later Life – Appropriation of an Integrated Transportation Platform

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ABSTRACT

We present the results of a design case study focusing on supporting the daily transportation of elderly in Germany. We conceptualized, developed and studied the appropriation of a transportation information system intended to ease switching between different transportation modes. Based on a literature review and a context study with 21 interviews we explored routinized transport mode usage and barriers when switching between modes. Iteratively, we co-designed a transport platform accessible via a website, a mobile app, and an iTV app. We further looked at the appropriation of the platform into the daily lives of 19 persons. Studying the appropriation highlighted different factors that facilitate the adoption of alternative transport options. The factors included reducing uncertainty, complementing transport information with context information (e.g. weather) and providing informational access based on the user's preferences as well as fitting in with the situational needs (activity related).

Author Keywords

Transportation; Mobility; Elderly; Participatory Design; Qualitative Research.

ACM Classification Keywords

H.5.2 User Interfaces - User-centered design

INTRODUCTION

Mobility is an essential part of modern society and a prerequisite for autonomous living. In later life, this participation and autonomy are challenged by various factors such as diminished driving capabilities, reduced financial resources and shrinking social networks. This can force the elderly to deviate from previous routines. At the same time, combinations of existing and new modes of mobility may, while offering new possibilities, require an adjustment over time to establish new routines. When these transitions are forced upon people, adopting alternative transport options [33] can affect one's perceived wellbeing in later life [52]. For example, when people need to give up driving, switching instead to public transport: The fact that they have no knowledge of how to retrieve necessary schedule information [48] renders common activities such as accomplishing daily errands or visiting friends cumbersome. Of course, "the elderly" or "older adults", are a very heterogeneous group, with multifarious biographical, social backgrounds. The sample we present is not necessarily representative of all the problems encountered by this population. Works in gerontology or social science [48,77], HCI [33,47], and especially transportation research [52,59,63] have examined mobility choices; both preferences that influence adoption as well as the drawbacks of specific modes which prevent people from using particular options. Yet these studies often have a very rationalistic viewpoint, typically focusing on logistical and infrastructural influences on the pattern of mobility. In this paper, we try to understand transportation habits from a user's perspective; specifically, how they are embedded into everyday activities. Based on an intermodal transport information system [7,47,68], we want to understand the factors that facilitate the adoption of those transport options, potentially extending one's set of commonly used transport modes. By doing so, we hope to lower the impact of barriers encountered during aging, allowing older adults to maintain or even increase their wellbeing in later life.

Based on a literature review and an empirical context study, this paper provides a deeper understanding of how the elderly routinely use different modes of transportation and also how and when they diverge from these routines. Subsequently, we show the results of a long-term "in the wild" appropriation study of an intermodal transportation information system. The system design was informed by the insights from the context study and evolved from designing with participants of our study. We highlight both the necessity of, and potential for, integrating complementary, mode-independent information to support transportation in a situated, activity-oriented way. We argue that looking at transportation from this user perspective reduces uncertainty, fosters independence and autonomy and promises to facilitate the adoption of suitable transport alternatives.

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The paper is structured as follows: Section two highlights the challenges of switching between modes as well as the specifics of the elderly regarding transportation and is followed by the description of methods. Following the design case study approach [76], the rest of the paper describes an initial context study, the implementation and design of an intermodal transportation prototype and its appropriation study. We end the paper by discussing our results.

RELATED WORK

When it comes to elderly people, research typically emphasizes the general occurrence of physical impairments that coincide with aging [9]. It can be argued that focusing on these impairments and their consequences is a mistake [62] as older adults – even those in the upper range - tend to be in overall good health [62,71], which has led to more research on extending the wellbeing of the elderly [17] (e.g. in care settings [50], communities [49] and mobility [47,77]).

The Specifics of Older Adults' Mobility

The existing literature [47] highlights two other key aspects when it comes to the mobility preferences of older adults, namely "decisional autonomy" and "mobile independence". The first aspect highlights the fact that a transport mode not only needs to be able to address a concrete need (e.g. going to the theater every Thursday at 6 o'clock in the evening) but rather is assessed based on the opportunities it provides. The second deals with older adults seeking to maintain their independence when considering transportation opportunities. Independence means "being able to manage [the] daily mobility by utilizing [one's] own resources in accordance with one's abilities and without depending on others" [47]. The elderly, therefore, establish routines fostering their well-being in relation to these aspects. Nevertheless, transportation habits change in later life. Research in this regard highlights how mobility is affected by aging, based on the dimension of (a) quantified movement, (b) structural preconditions such as the availability of infrastructure, and (c) the before-mentioned focus on the physical status [77].

Regarding a), for example, one can see a decrease of trips after retirement, while in the US, the share of trips made using cars increases [62]. In Germany, senior citizens tend to continue to use the car and are generally more active [79]. Concerning infrastructure (b), Mollenkopf et al. argue that extended car usage is partly due to the fact that the proportion of older adults in western societies living in rural areas continues to increase, where access to public infrastructures and information about them is more problematic [48]. The paucity of this information additionally prevents elderly users from using alternatives to the car [24], which explains why the fear of losing their driver's license is common among older adults [63].

Habits and Transportation

HCI-research around transportation is mostly concerned with providing better access to certain transportation modes or assisting with specific tasks when engaging with one of these modes. Most of the common transportation modes have been researched, e.g. public transportation (PT) [21,27], walking [37], cycling [58], motorcycling [55], ridesharing (RS) and carpooling [12,29,47,54,69] and extensively car navigation (e.g. [28,38,41,42]). The focus of the studies within each mode varies greatly and it is beyond the scope of this paper to describe them all. Even so, several studies focusing on PT (e.g. [3,5,13,21,44,56,78]) deal with issues of payment [56], real-time information and waiting times [13,21,78], accessibility [44], and specific user needs [3] in order to increase the quality of service [59]. For example, Siira et al. [66] and Barham et al [6] demonstrate the possibilities inherent in integrating information about public transportation on a mobile device. Only a few studies exist in HCI which focus on behavioral change in transportation without being bound to a specific mode. Hasselqvist et al. [33] explore how people adopt more sustainable (car-free) transportation practices and Meurer et al. [47] identify motivations and barriers encountered by the elderly in using different modes, yet specifically focusing on RS. These studies highlight that understanding why and how transportation modes are routinized, how they can be effectively supported, and why they are difficult to change is of utmost importance [1,2,4,73] for supporting the appropriation of a new mode [30]. Typically, choices of transportation mode are closely tied to the respective travel goal [1] and to previous commitments (e.g. purchase of a car) [4]. New forms need to overcome established habits and provide extended benefits even when the person is predisposed to make use of the new form [73].

In this regard, people need to assess the appropriateness of transport opportunities. Several factors have been identified in literature such as shorter waiting times, reduced uncertainty, increased ease of use, willingness to pay, greater possibilities for the adjustment of travel behavior and more flexibility [18,20,21]. According to Redman et al. [59], those factors can be distinguished between "physical" and "perceived" attributes. The first mainly covers objective facts that can be easily observed or measured, such as reliability, the condition of vehicles, frequency, and accessibility. The latter category deals with the subjective experiences of the passengers such as experienced comfort, feeling of safety or perceived overall convenience. Redman et al.'s attributes are useful for understanding the attitude towards the adoption of PT as an alternative mode, and mode switching in general. For example, they suggest that monetary factors (e.g. free PT; increasing cost of private transportation) have an effect on the willingness to switch from private cars to PT initially [22], yet need to be complemented to sustain the transition [64,70], e.g. by increasing the level of convenience [15], shortening travel times and increasing the frequency of the services [19] or by providing live information [45]. Redman et al. [59] conclude that a superior level of service quality in certain dimensions

of one mode is the main cause of lack of demand in other modes, such as RS (e.g. [14,32,57]).

By looking at a more specific set of users, we may better understand the appropriation of new, potentially beneficial, transportation options. To do so, we will present our findings on the design and appropriation of an intermodal transportation information system. While all the aforementioned studies highlight important factors, there are only very few design concepts dealing with multi- or intermodal solutions [31] and - to our knowledge – no studies in HCI reporting on the appropriation of such integrated multi- or intermodal solutions from a user's perspective (although appropriation more generally is widely discussed. See e.g. [16,23]).

METHOD

	Context Study	Evaluation Study
Number of participants	21	19
Age distribution	Min: 58 Max: 80 Average:69	Min:60 Max: 82 Average:71
Mode usage (multiple)	Car: 17 PT:5 Ridesharing: 9	Car: 15 PT: 5 Ridesharing: 7
Area	Rural:11 Urban: 10	Rural: 10 Urban: 9

Table 1: Details of user sample

Our study presents a design case study [76] and is based on a long-term Living Lab approach over a period of three years (February 2012 until January 2015). We define the Living Lab as a "user-centred, open innovation eco-system based on a systematic user co-creation approach integrating research and innovation processes in real life communities and settings" (openlivinglabs.eu; [8,26,53]). The basic point of Living Lab methodologies is to introduce new and innovative technologies into what are, as far as practicable, naturalistic settings. Typically, they are also associated with mixed methods. Although many studies of this kind have been centered on the home, there is no particular reason why research of this kind cannot be extended to the wider community (see e.g. [23]). Our study was part of a research project on the mobility practices of older adults in Germany (Figure 1) based on interviewing, observational work and Participatory Design principles [11]. Our interest is in designing tools to extend wellbeing in later life [62,71] and to learn from the specific case we look at.

Participants (see Table 1) came from a region that includes both urban and rural areas with approximately 280,000 inhabitants in total and 100,000 inhabitants living the main city. PT options in the region are the bus and the train (train is mainly used for inter-city travel). Bus services are limited in some rural areas which are mostly inhabited by older adults. The region is hilly with diverse terrain.

The participants were equipped with an Android-based Smartphone in May 2012. During weekly meetings, they received support in how to use the device for basic tasks (using it as a "daily device" for tasks such as calendar management, messaging, transportation, phone calls etc.). After this appropriation phase, the weekly meetings were mainly used to conduct co-design workshops (more than 40 workshops with 6-10 participants on average; see section "Iterative Design of System"). The iterative design phase ended in August 2014. Participants continued using the prototype until the end of 2014. We then conducted 19 evaluation interviews in conclusion.

Context Study and Evaluation

To collect data, we conducted 40 interviews in total. 21 interviews were conducted in participants' homes before (initial interview study) and 19 interviews after (appropriation interview study) we developed our prototype. Two participants of the initial interview study did not take part in the later phases (co-design, evaluation) of the project. A further two participants dropped out during the project and were replaced by others. The interviews were audio-recorded and transcribed verbatim afterward. After transcribing the interviews, we conducted a *content analysis* [46] to identify significant themes. The duration of interviews depended on the preferences of the interviewees and thus varied in length from 45 minutes to two and a half hours.

We conducted the initial interviews together with project partners, and analyzed focusing on diverse aspects, e.g. with regard to opportunities and obstacles of RS [47]. Our analysis was design-oriented and focused on how transportation is routinized, and analyzed the reasons people have for deviating from these routines. The interviews centered on problems regarding the transportation habits of

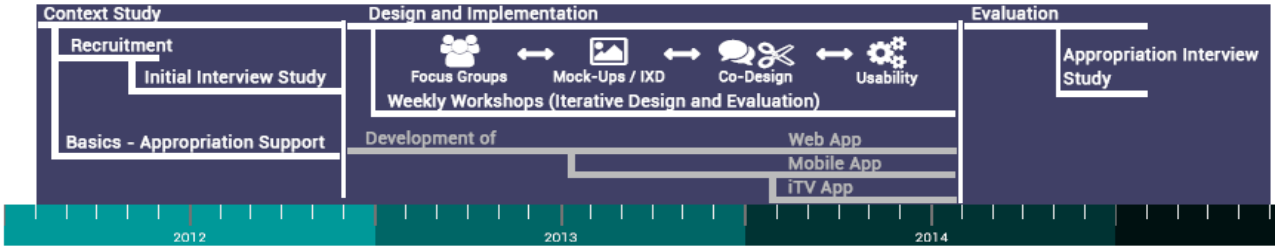

Figure 1: Long-term Living Lab Process

the elderly. We were especially interested in the organization and planning of the interviewees' daily transportation to understand their reasoning regarding transportation choices to reveal potentials for ICT-based support. The analysis resulted in different codes which were collectively clustered into several topics, like 'usage of transportation modes,' 'planning of transport,' 'cooperation in mobility', and 'self-perception of abilities in older age'. Based on this, we further developed the categories presented in the later section.

In the evaluative interview study focusing on the appropriation of the tool (Figure 1 - "Evaluation"), we focused on the integration of the prototype into the participants' daily lives. Although we already had the chance to see routine use developing at the weekly meetings (Figure 1 - "Design and Implementation"), we were iteratively developing the application and therefore conducted a second interview study at the end of 2014 in which we asked about the influence of the prototype from the participants' point of view. We identified the situations and tasks for which our application was deemed useful, as well as situations where participants stuck to their existing tools and routines or situations in which they made use of other tools that they had become aware of since the introduction of the smartphones. The users' long-term involvement in the design process allowed us to build a trustful relationship [51] and further enabled us to observe the appropriation of our (and other) application(s) over time. This in turn helped us to understand the situations and issues described by participants during the second study.

Figure 2: Participants design the iTV-interface

Iterative Design of the System

Between the two interview studies (Figure 1 - "Design and Implementation"), we engaged in over 40 co-design workshops with the participants in order to design a mobile (Figure 3 and Figure 4), a web and an iTV application for integrated transportation information services. After the "Basics - appropriation support" phase (Figure 1), we conducted workshops to understand how an integrated transport information system might be designed. In the beginning, the workshops focused on existing practices regarding different transportation modes. We further introduced available tools, such as flinc for RS or DB-Navigator for PT (official app of the German Railway System). Based on these steps, we first developed paper-based mockups that we discussed with participants. Due to the complexity of the system, in some cases we provided initial ideas and conceptual solutions, using their critique as a resource for further designs [74]. In other cases, we conducted workshops and asked users to design interfaces (Figure 1 - "Design and Implementation / Prototyping"). For example, we conducted a co-design workshop to design the layout and select the functionality of the iTV application (Figure 2), whilst another one tested different interaction prototypes to negotiate RS arrangements and a further workshop dealt with privacy, using card sorting to identify relevant information structures and sharing preferences.

CONTEXT STUDY – CURRENT TRANSPORTATION ROUTINES OF ELDERLY

In the following, we will outline the results of our context study. We structured our results according to two sets of criteria. The first deals with resources, knowledge, and skills that participants mentioned as relevant. The second deals with contextual factors influencing the reasoning. The study aimed to understand how older adults choose transportation options in their daily life, verifying and extending existing findings in the literature.

Resources and Knowledge at One's Disposal

To understand how people adopt different transportation modes in everyday life, it is necessary to understand the opportunities created by infrastructures and resources. Our participants described various aspects that show how transportation infrastructures (of different modes) are understood as mobility resources:

"As long as I can still walk to the bus stop, I'll use the bus, I'm happy. It's my independence. I'd like to stay independent actually. And for me, that means the bus. Not the car, because I don't own one." (Female1, 73, PT)

"I'm lucky to have my children around, at least some of them live here. And if I call them, they take me wherever I want if they are available." (Female3, 73, PT)

The quotes highlight the importance of resources, including a strong social network or the physical capability necessary for organizing one's mobility. These are typically strongly connected to individual situations. A lack of capability, for example, can render specific modes unusable. A comment by one of our participants highlights how he is not able to use PT but instead uses the car to reach certain destinations that are not in close proximity to a bus stop.

[Talking about the ticket fares of PT] For me the determining factor is, 'where does the bus stop?' and 'how far do I have to walk to my destination?', it's down to my problems with walking. I might walk 500 meters or even a kilometer but I think there is more to it. For me, walking is just getting worse." (Male1, 81, CAR)

The quote points to another important issue. To make use of certain travel opportunities, people need not only to be aware of the opportunities but also require certain knowledge to make use of the available options (‘*where does the bus stop?’)*. This knowledge becomes especially important when switching to new or unfamiliar modes. It consists of what we might call operational strategies. For example, one participant describes such a strategy regarding PT:

“The timetable often changes, just a couple of minutes, and when you’re going out, you think ‘Oh yes, you still have time’ but then you see there is nobody standing at the bus stop anymore. And you think to yourself ‘has the bus already left?’” (Female3, 73, PT)

Car owners often described a total absence of such knowledge with regard to PT. They pointed out that it prevents them from switching to PT in many situations. More generally, our participants highlighted issues with “translating” their knowledge into information that can be used in different transportation modes. Thus people often referred to personal landmarks when describing locations, referring to personally meaningful expressions such as “to my brother’s place”, “the supermarket” (having a specific or a set of specific supermarkets in mind) or names used locally names which were not officially documented. Other place references were personally or socially constructed and imply a certain understanding of destinations and activities (e.g. people mentioned “the computer club” when talking about a course on computers for senior citizens that takes place weekly in the area), like regular meeting points with friends, e.g. one participant referring to the gym by saying “doing sports”.

It becomes obvious that the participants acquired knowledge and developed strategies for their daily routines and modes of choice. While participants wanted to maintain their familiar routines and available resources (especially car owners), they also described specific cases in which explicit factors led them to deviate from routines and switch modes. These situations are particularly interesting as they allow us to understand our participants' reasoning and identify factors that come into effect regarding the use or non-use of a transport option.

Reasoning on Transportation Options

In this section, we will explore the various situational influences when settling on a transport option. For instance, taking the bus to the city center eliminated the need to search and pay for a parking space. These advantages were often recognized spontaneously and triggered the rescheduling of activities. This was typically indicated by quotes such as “since I’m already in the city center” or “as I’m taking the car/bus anyway”.

“If you’re going on the bus anyway [instead of walking], you might as well buy groceries before you go home.” (Female4, 73, PT)

Most participants reported that they would continuously (re-) compile their “personal schedules”. This requires continual access to information to ensure that rescheduling is possible on the backdrop of the transport mode being used. Throughout this rescheduling, participants tried to align the activities’ temporal and spatial conditions with the options provided by the various modes. A common issue is that certain activities cannot be precisely scheduled in advance as they imply vague restrictions on time and destination - they entail a certain degree of temporal flexibility.

“We can’t do it all today, there isn’t enough time. […] You simply do the rest the next day. You plan things ahead and it works out. And even if it doesn’t work out, you just say so – but we have more time than younger people anyway.” (Female1, 73, PT)

“You can just sit in the bus shelter or whatever – you’re sure to see a neighbor passing by, purely by chance. You strike up a conversation and time flies when you get chatting. […] It sometimes happens that we’re so immersed in conversation that you completely forget the time… And when that happens, I just catch the next bus.” (Male3, 66, CAR/PT)

The quotes demonstrate that participants anticipate deviations from schedules. People engage in numerous activities which imply temporal constraints. For instance, the examples above describe very loose time constraints. Such activities can easily be incorporated into the schedule and can easily be rescheduled. The need to be temporally flexible goes hand-in-hand with the fact that some activities do not require a specific destination. Or from a practical point of view, certain activities might be carried out at diverse locations, resulting in an interchangeability of destinations:

“I just check out all the little stores and it doesn’t matter to me what kind of store it is. As I said, I buy my groceries in the stores that I think stock what I need."(Female5, 75, CAR/PT)

This process of scheduling is summed up by a participant talking about activities with fixed times and places which nevertheless provide an opportunity to schedule in other activities:

“Sometimes things are already planned [in terms of having fixed appointments such as visiting the dentist]. You know you are going to a certain place, so you know things that can be done there. For example, at the town hall, I can drop things off there or whatever. It’s natural to combine things like that.” (Female1, 73, PT)

This respondent used the town hall as a reference point to consider possible activities. In this case, the town hall is located in the city center where several other stores and also the postal office where “one can drop things off” are located. This shows that spaces do not always determine activities or vice versa. For instance, instead of using one’s usual post office, one may mail a package from a post office near the town hall in order to combine the mailing activity with the town hall errand. Owing to temporal and spatial flexibility, an activity may be associated with several directions and vice

versa. In this regard, existing literature [47,54], stresses the importance of flexibility. Transport options need to provide a sufficient degree of flexibility (temporal and spatial) to be adopted. If options lack this degree of flexibility, people are unable to align their activities to the offered transportation services and thus are unlikely to switch to those modes [59].

Considerations for the Design of Systems Supporting Transportation

To provide new transportation opportunities for our participants, especially in areas where infrastructures such as PT are sparse (e.g. rural areas) or existing concepts such as Uber or flinc fail due to a lack of critical mass, we derived design implications from previously presented studies (see related work) and our complementary interview study. We outline the challenges and guiding themes for the design of our prototype in the following.

Awareness about available transport opportunities

One implication highlighted by Meurer et al. [47] and which has been further confirmed in the interview study is that older adults want to be aware of the opportunities available. Thus solutions need to incorporate different information sources to extend the user's options. For example, a system could provide the user with multi- / intermodal transport information to explore and compare all available opportunities. Even if the information on the various transport modes is not used, its availability might conceivably help to increase one's decision-making autonomy [47], and the integration of this information also addressed the issue of access to information on unfamiliar transport modes [24,48]. Generally, easy access to information on multiple modes makes the adoption of other transport options more likely [59].

Ability to make use of transport opportunities

The promotion of autonomy is an important aspect of the mobility of older adults. For this, being independent of others is a crucial requirement. As shown in our interview study, retrieving relevant transport information necessitates not only knowledge about existing opportunities but also operational knowledge regarding different transportation options. This is in line with the existing results for the specific case of the elderly [24,47,48] but also has more general implications with regard to access to relevant transport information [59]. Further, the steps to make use of a transport opportunity, e.g. payment, should be integrated [15]. Generally, information should be individualized to provide more benefits. Prior work on single modes has shown the necessity of features such as retrieving individual schedules in PT [21,34] or providing carpooling and RS opportunities based on similar whereabouts. See [10,60] who developed a system for PT for retrieving individual schedules.

Taking into account context and reasons for travel

The analysis showed that many decisions with regard to transportation are made taking into account a variety of information both contextual (e.g. the weather) and social (e.g. meeting people at the bus stop). Additionally, this decision-making often takes place prior to travel (e.g. considering activities which can be combined with fixed appointments and destinations), as well as spontaneously while traveling (e.g. finding suitable destinations close by, such as groceries). Thus, the user needs to be able to retrieve information relevant to his current situation and the service should therefore meet the requirements of the passenger's activity. For example, information about the frequency of travel opportunities (e.g. in PT [19]) can inform reasoning and allow rescheduling. Further personal preferences / requirements in terms of comfort and safety [59] should be taken into account as well as the situational implications of the intended activity (e.g. by integrating third party services and appropriate interaction mechanisms)

DESIGN AND IMPLEMENTATION

Based on derived implications we created a prototype. The development was twofold. The selection and integration of services were conducted in an iterative, co-design process [76]. We developed the necessary backend systems, which allow the integration of different transportation providers, event calendar sources and map services (including routing capability).

From a user perspective, the prototype is a platform allowing users to retrieve intermodal transportation information. The main goal of the prototype was the aggregation and combination of all available transport modes within a specific region. We included RS, PT, taxi services and special needs transportation services, the information about which could be retrieved using either a website, a mobile app or an iTV app. The inclusion of additional information, such as the event calendar or POI information was an exemplary result of the co-design process.

The interaction was designed in a way that it created awareness about transport opportunities nearby (Figure 3) by showing all the available options for a given location. The search interface provided unified access to information about all modes. The location was either entered by the user or automatically retrieved using GPS. The idea was that awareness about available transport opportunities would lower the barrier to certain modes whilst simultaneously allowing the experienced user of a mode (especially PT) to retrieve relevant information quickly, such as imminent departure times. As soon as the user entered a destination (Figure 4), the results showed different itineraries consisting of combinations of all available modes. The user can of course enter preferences, e.g. to exclude certain modes from the results, slower walking speeds (for connections within PT) or required space for luggage etc. The user can define default values, which can be adjusted for each search if necessary. The user can also make use of a classic click and text-based input. Further, they can use a map to choose locations or enter search requests via natural language voice input. In addition, point-of-interest (POI)-based and "event-based" destination inputs are provided. POI-based input

allows users to choose from different venues using the foursquare API (https://developer.foursquare.com/). Event-based input allows users to browse upcoming events in the test region that were retrieved from a calendar of public events. When users looked up travel information for such events, the system automatically takes time and the destination of the event into account. The speech input function could parse natural language sentences by searching for tokens in the sentences, such as relative or absolute time inputs ("tomorrow", "in ten minutes", "at three o'clock"), addresses and venue types (e.g. "restaurants"). Various transportation modes were included to address users' awareness of available resources. This was further addressed by always showing nearby transportation modes whenever the app was started up. The map-based input, the generic search interface and other features (e.g. exploring POI databases or upcoming events) addressed the issue of lack of knowledge due to unfamiliarity. Our aim was to provide the user with the opportunity to access different kinds of transport information without the prerequisite of having specific mode-related (e.g. names of bus stops) or local (e.g. addresses of places) knowledge. We further took location into account by using GPS information and showing nearby facilities. Further, we provided features which allow the user to enter venue categories and then choose from available alternative destinations based on his or her intended activity.

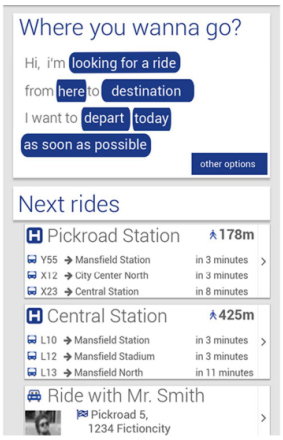

Figure 3: Start screen without destination

Figure 4: Start screen with destination

APPROPRIATION OF THE PROTOTYPE

In this section, we outline aspects arising when participants used the prototype "in-the-wild". Users were free to use whatever tools they liked and we did not limit our observations to assessing the appropriation only of our prototype but also paid attention to the various tools and strategies that were evident. During the final year of the project, our prototype was used more than 500 times per month resulting in about 11,000 sessions in total. The monthly peak usage was 3,800 sessions due to local TV reports. Access was achieved 60% of the time using a mobile device and 40% using a desktop or the TV app (combined).

The study revealed blind spots in existing literature that stem from a strong focus on (mode-specific) transportation factors. The appropriation study helped us to understand the extent to which increased awareness and better access to relevant transport information as well as extended (contextual) information influenced the participants' willingness to adopt new or different transport options.

Reducing Uncertainty

Generally, the prototype was positively received. The participants especially liked the regional focus of the tool, which was mainly established by integrating a local event calendar as well as selected design elements (such as the header image) which resembled landmarks of the area. As most of the participants did not use any ICT-based tools to support their transportation before the project (except for car navigation systems), we were interested to discover in which situations and for which tasks they would use and adopt (transportation) tools. One interesting point was the time of usage and the specific incentive to use the app. We expected that users would appreciate the mobile app for getting information on the go, but to our surprise they pointed out that they use the mobile device for the careful planning of trips in advance:

"Occasionally I check departure times when I'm in bed late at night or early in the morning. I think you [addressing the interviewer] have a different way of doing that. Rather off the cuff." (Female4, 73, PT)

The quote illustrates that checking in advance was used as a means to reduce the uncertainty caused by a lack of experience with the device (as she points out, the interviewers are more capable of coping with the task spontaneously). Yet mobile access to such information also reduced uncertainty regarding one's mobility. For example, Female11 *(PT, 82 years)* compared two situations before and after familiarizing herself with different apps. Once, she found herself lost at an intermediate train station, helplessly trying to find an alternative connecting train after arriving late. Nowadays, she points out, *"the phone provides [her] with security"* when otherwise disoriented; anecdotally telling a story about how she managed to find the way back to her hotel using her phone to find an alternative route when some streets had been closed due to construction sites. Several participants outlined how easy access to information helped them to validate trips generally:

"Sometimes you have to change buses, and you can check if there is a better connection" (Female4, 73, PT)

It became clear that people appreciated the ease of information retrieval using ICT, which allows access to information *en route*. Yet the mobile app was also used within the users' existing routines for planning things:

"I won't always bring the smartphone in future. I don't need it. I'm happy to have it at home, especially for the internet and when I want to check things such as the buses. Or events.

That is the really great thing about our app." (Female7, 78, CAR/PT)

It was surprising how strongly the "always on" characteristic of the mobile devices was highlighted. The mobile phone and the app provided easy, spontaneous access to information related to transportation and was therefore used more than the desktop web application. Generally, by extending participants' access to information they felt more aware of opportunities and more confident of finding suitable options.

Situated Exploration of Opportunities

The introduction of the technology turned out to influence the participants' (perceived) flexibility. While the prototype sometimes blended in with existing routines, it also became clear that the appropriation of the tool(s) and the influence it had on existing routines was very different depending on one's prevalent transportation usage. Participants who mainly used PT for their daily trips reported greater benefits from using the technology as assistance. Even in the case of very regular PT users, the application helped to create better awareness of the available opportunities:

[Talking about search results containing different alternatives of going to the city center from the participant's home that had not been expected by the user]
Interviewer: Why do you think this result is wrong?
Female3: This connection doesn't head to the city. It ends up in [VillageName]. [Female3 recognized that this bus is just the first part of the whole trip]
Female3: …Then I can board Line 555 in order to get to the cemetery. AND [recognizes that the connection is a suitable alternative] this is important to know, that there is an alternative to the main connections. It's really interesting that this information is programmed into the application. Very nice! (Female3, 73, PT)

With the prototype, users even established new ways of retrieving information, abandoning tools they had previously used such as writing down departure times before going somewhere. The prototype enabled more flexible scheduling within their daily tasks:

[Talking about information on PT]:
Interviewer: Did you use the printed timetable before?
Female3: Yes, I always wrote down the departure time before I went out.
Interviewer: And now, do you check the time on the move?
Female3: Yes, you do not necessarily know in advance when you will be going back. If you have an appointment or just stroll around the city.
Interviewer: And how did you deal with that before you had the phone?
Female3: I always wrote down several alternative departure times for the return journey. (Female3, 73, PT)

The two quotes highlight how the application helped to facilitate flexibility within daily activities - on the one hand by providing more information *("…this is important to know, that there is an alternative to the main connection...*") and on the other by facilitating access to this information (using a phone instead of writing down departure time in advance). This interest in information providing new opportunities in each situation was not limited to PT users but especially extended to car users. Even though car users rarely use other modes of transportation, they reported instances of information retrieval, such as looking for events to visit, POIs or PT connections and RS out of curiosity:

Male4: [Being asked if he uses the prototype for PT] Rarely, since we usually take the car. But that doesn't mean that I never use it. Just recently, we went to [CityName] and we liked it there. So I thought about going there again and checked out how to get there using buses and trains. […] At that time I used the German railway system app because I knew it from the computer. But I used our app when we visited our children. I wanted to know what the PT-situation is over at their place. Even there [He emphasizes the fact that information is available because the children live in a very rural area] our app tells you where the next bus stop is and how to get there. (Male4, 71, CAR)

What makes this quote interesting is that the app allowed him to retrieve the information necessary to make use of PT in the situation he found himself in even though he was not actually using PT. We found that participants were generally interested in exploring all avenues of possibility, both in terms of available transport options as well as potential destinations. In this sense, the integrated calendar provided a strong incentive to use our app. Thus, the inclusion of "mode-independent" complementary information can serve as a starting point for becoming aware of other mobility options. All participants highlighted the prototype's event calendar in this sense. Most of our participants pointed out how they just opened the application to look for interesting events and simultaneously became aware of alternative transport options:

[When browsing events in the event calendar] "And the app provides me with alternatives for getting there and I can think about whether to take the bus or the car." (Female8, 65, CAR)

The extent to which the calendar was used and pointed to as a central part of the application was unexpected but shows how browsing for opportunities might lead to experimenting with unfamiliar transport opportunities. Thus while the integration of various transport information was necessary, additional information for certain activities can point at the suitability (or even advantages) of alternatives for a certain activity. For example, after familiarizing herself with our app, one user thought about using PT to visit her sister in hospital as parking spaces are limited. In this case, for example, the suitability of PT could be highlighted by providing timetables alongside the visiting hours of the hospital.

Integrating Transportation and Daily Activities

As exemplified above, participants of our study constantly described situations in which they made use of options because it was suitable for their intended activity. However,

participants also described situations where the shortcomings of our prototype were evident:

[Talking about the provided details of a connection, one user demanded more information, yet the application did not provide any further information about the route at this point] "I wanted to see the whole route. See which way it goes. Because that would be interesting. For example, if I get on bus 333…it also goes to the city center…yet it takes a detour through another part of the city. If I take this one… tough luck! So it is interesting to know which route it takes." (Female7, 78, CAR/PT)

The quote highlights how the information required is not limited simply to the details that enable the interviewee to get to their destination, but that the information provided needs to support flexibility or provide additional opportunities for scrutiny. In this regard, PT users reported using different applications for different contexts, e.g. they used the official application of the German railway service for longer journeys, but our app for traveling within the city. Even though both applications provide the same PT information, they integrate different additional services (e.g. ticket reservation in the official app and POI services and local events in our app). The example of the event calendar showed that the information our participants made use of was not limited to "logistical" information bound to any mode. We expected POI information to have a similar incentivizing effect, yet the users cared much less about POI than about events. When we questioned this, it transpired that most of the categories within the POI databases consist of venues the users already knew. As a result, browsing the POIs was not such a great incentive to use the application as information about events was. Nevertheless, POIs turned out to be of value to the participants, with a very specific focus on the utility of places:

"So, I really would like to see information on toilets being integrated into the application. Information like this should be available. That's quite useful for elderly people like us. Some years ago, that issue was quite challenging in the city." (Female10, 63, CAR)

Here the situated value of information for transportation is highlighted and how it renders an infrastructure or destination suitable (the ones close to public or accessible restrooms). It becomes apparent that the availability of contextual information when deciding whether or not to consider a certain mode when engaging in a certain activity is crucial. In another example, a participant outlined which different modes she takes into account and how this is influenced by the availability of information:

Female7: „For example, when my sister visits, we usually go to Italian restaurants. And then I look where the closest Italian is."
Interviewer: "Do you look for the closest one?"
Female7: "If we walk, I look for the closest. But she has a car, so I can look for places we can drive to." […Talking about how to choose the best venue…] "I would choose the nearest venue. Or… I mean..., if it is easy to get to, why not catch the bus and walk a few meters. This thing [the app] is quite helpful." (Female7, 78, CAR/PT)

The quote describes how POI information can become useful when a sister's visits. In this case, she and her sister do not prefer a specific Italian restaurant and therefore several destinations are interchangeable. Compared to the example provided by Female10, which shows how information on specific POI (such as toilets) can render certain routes (and therefore modes fixed on those routes) dispreferred, the example of Female7 shows how information about the accessibility of POIs influences which destinations and modes people consider in the first place when deciding on trips. It becomes obvious that POI information (including its reachability) serves to allow participants to explore their options in terms of destinations and transportation.

This focus on the situational use of the system became even more critical for RS. The RS feature of the application was used only rarely, resulting in no matching of offers and requests even after the system was made available publicly. We asked for reasons why the feature within our app was not used. In many cases, people complained about the necessity of planning and entering trips in advance to publish the request or the offer. This caused issues of critical mass that rendered the RS feature not very useful.

"I seldom use the app. Sometimes I open it out of curiosity, but I've never needed it. I like the way it is designed and I can see the PT connections. But you only start using ridesharing when you are sure that someone will reply. It's a dead end right now". (Female9, 60, CAR)

In cases where we could observe RS (e.g. when people joined a ride to visit our weekly meetings), people preferred to use a messenger, as it allowed them to offer a ride more spontaneously. Utilizing an messenger as the tool of choice for RS highlights how participants sought to maintain flexibility while extending their RS network (which was previously limited to family members and close friends). We expected people to adopt RS because of the increased awareness facilitated by being presented alongside other options. Our concept for RS, however, was not always suitable for the users' everyday mobility. It mostly followed concepts of established long-distance RS platforms and hence was inappropriate for daily, short distance travel, as it requires people to plan in-advance, causing conflicts with users' independence and decisional autonomy [47].

DISCUSSION

Based on the literature and context study we expected our participants to appreciate the integration of different transport information into one system. As the literature [47,54,59] points out, the flexibility provided by a transport option is crucial to its adoption into daily life. Hence, we anticipated that the extended awareness about travel options provided by our tool would increase the participants' flexibility. In particular, we found that ubiquitous access to

detailed information can reduce uncertainty, thereby fostering independence and increasing autonomy [47]. It allowed the participants to assess the suitability of transport options for certain activities and personal preferences (e.g. finding the shortest connections and not being "trapped" in a bus, forced to take detours). The example of our RS feature, which was largely rejected, highlighted the importance of this fact. Users saw greater potential in messengers for supporting their current RS practices (e.g. using group chats to offer rides). In this regard Wash et al. [75] have already argued in favor of informal RS communication. They allow users to easily negotiate details and spontaneously offer rides and can be easily integrated into daily routines [59]. Thus, they restrict one's decisional autonomy to a lesser extent [47] and allow for leverage of existing social structures [12].

Yet above all, our study highlights that fostering the adoption of new transport modes by dint of incorporating transportation information can be further enhanced by the addition of complementary situated and contextual information, e.g. the event calendar which provided up-to-date information about upcoming events. This information motivated participants to look for transportation options, tempting them to look at alternative modes of transportation. The recognition of alternative modes of mobility can be seen as the first step towards challenging routinized behavior [1,2,4,30,73]. The POI information, on the other hand, became relevant within a given situation where specific needs arise (e.g. finding the closest toilet or a restaurant). This is in line with arguments made by Redman et al. [59], stating that the ease of integrating an option into one's daily activities is of utmost importance for stimulating and sustaining adoption. It is also in line with existing findings regarding specific modes of transportation, such as PT [25,59] or RS [47,54,75].

The findings on the appropriation study help to illustrate the findings from the context study and prioritize them from a user's perspective. They indicate that it was not necessarily a question of being aware of all options (as shown in [24,48,59]), but rather of being aware of the information that highlights the *situated appropriateness of an option in a given context.* Focusing on a particular context instead of creating awareness about *all* options addresses a common problem of "mode-oriented" concepts that merely focus on infrastructural and logistical aspects. Modes are not simply interchangeable, but, as Hasselqvist et al. [33] showed, transportation routines are established in relation to specific activities (e.g. daily errands, visiting friends, etc.). The rejection of RS in favor of WhatsApp as well as the strong interest in the calendar highlighted that appropriation of transportation tools is highly contextual and "in-situ" studies are needed to understand "how technologies are 'domesticated'" [67,72,76]. Therefore, concepts aiming at the adoption of various modes need to support the establishing of new routines for certain activities instead of just providing alternative logistical information.

While existing concepts, focusing on single modes, start to reflect personal needs (e.g. in PT [25,35]) or provide more situational relevance (e.g. in RS [60]), they remain "mode-bound", mostly adapting the logistical information to the user's needs yet often neglecting unintended uses [36,39] or other interactional factors [40,61]. Our findings offer design opportunities and approaches for overcoming this shortcoming. Acknowledging the "turn to practice in HCI" [36,40,61,65], our study shows that tools establishing new transport routines [1,2,4,30,73] need to align relevant information with the context of a practice to transform it. We have argued here that understanding how these factors come to be integrated requires a long-term approach, one which is geared to understanding how users appropriate functionalities over time. In this manner, we go some way towards discovering what works and what does not. The major limitation of our study, we feel, is scalability. We do not know, as yet, whether the results we report here would be valid, for instance, for a large, urban, environment where complexities are multiplied.

CONCLUSION

In conclusion, we found support for the findings of our context study, namely increased awareness about options, the consideration of personal knowledge and ability (e.g. in terms of "personal information spaces" [25]) and the importance of 'local' reasoning (e.g. taking into account contextual information [34,43]). Yet the results of the appropriation study stress how the relevance of information for the user depends on his/her situational requirements. Based on the user's activity (or intention), the interplay of different kinds of information is required, including non-transport related information such as weather, alternative destinations or activity-related restrictions and implications (e.g. starting time when going to the cinema). In addition to existing studies which mostly highlight logistical information and transportation infrastructure, we argue for an integrated understanding of transportation and the user's practical intentions. Regarding the adoption of different transport options, understanding this intention serves two purposes: 1) It provides opportunities to create awareness about existing alternatives; and 2) it highlights the necessity of providing information allowing users to assess the suitability of options. Therefore future support for transportation needs might integrate activities, events, alternative modes and other contextual information in an even more detailed and sophisticated way. Methods for personalizing information resources of this kind would, we feel, be one such useful future direction.

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