PROTOTYPING AN AUTOMATIC AND CONTEXT-ADAPTIVE ACQUISITION METHOD FOR MOBILITY PREFERENCES OF PASSENGERS IN PUBLIC TRANSPORT

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ABSTRACT

Planning a trip on public transport is an important step that can be time-consuming and nerve-wracking. Finding the right connection is not always simple, especially since personal preferences influence the selection of the most suitable route. Finding the most suitable route passenger's mobility preferences need to be known by the journey planning system. However, collecting these individually mobility preferences is a time-consuming process. Our contribution applies the contextual inquiring method determining what mobility preferences are most important. Based on these findings, we introduce a prototyping approach automatically determining four of the most important mobility preferences. The detected parameters are used to enrich user's future trip requests, assisting passengers to have pleasant and stress-free journeys from door to door.

KEYWORDS

Detecting Mobility Preferences, Individual Passenger Information, Context-Adaptive Public Transport Information, Contextual-Inquiring, In-App-Questionnaire, Evaluation in Public Transport Domain

1. INTRODUCTION

Travel planning in public transport can be performed on various platforms, including websites, ticket vending machines or smartphones. Due to their great flexibility, smartphones are used in many daily areas, be it shopping, communication or entertainment. The application areas are almost limitless and are becoming more diverse and complex every year. Two of these areas of use are timetable information and travel planning for users. What used to have to be read off information boards or awkwardly folded information maps can now additionally be conveniently accessed from anywhere on the Internet. Added to this is the possibility of personalization, i.e., an experience adapted to the user. A novel term that comes up in this context is "mobility preferences." Mobility preferences are essential for personalizing trip planning. They make it easier for the user to find connections. Likewise, they help the route calculation system in the background to create a customized and individual response. In interaction with journey planner applications installed on the user's own smartphone, optimal route information can thus be offered. According to a 2017 survey, 80% of respondents, aged 18 to 29, reported using their smartphone for connection information (Statista, 2020). A more detailed examination of route requests was carried out in a student thesis at Karlsruhe University of Applied Sciences. The investigation of route requests in the Karlsruhe area led to the conclusion that only a minimal number of requests with additional parameters are performed (Keller et al., 2022). For example, about 25,000 out of 18 million requests were performed that included an additional waypoint. The need for ground level access was indicated in about 5000 requests. A change in walking speed was included in about 55,000 requests. Specifying other parameters was possible, but was done in rare cases. Our contribution aims to provide information about possible reasons. The focus is on the use case in which users have already decided to use public transportation.

The goal of this work is to support users in their travel planning in order to achieve a personalized experience on the one hand and to efficiently use the available resources and potentials on the other hand. Various factors are necessary for this goal, first and foremost mobility preferences. Users specify these only in rare cases. To address the problem, the following two research questions were defined. First, what are the reasons for situational and individually made travel planning decisions? Secondly, what are the reasons for not indicating mobility preferences? To answer these questions, a user study is conducted. The results of this study form the basic building blocks for a concept that will help solve the problem. A system that supports users in specifying their preferences or takes them off their hands will be conceptually designed and tested with our prototype. The results will provide information on possible improvements and pave the way for future work or studies.

Our paper is structured as follows. In the next section, we look at approaches defining individual mobility preferences and finally set definition mobility preferences for this work derived from literature. We will then look at prior published approaches towards context-adaptive acquisition methods for mobility preferences of passengers in public transport in the related work section. Following this section, we will describe our methodology subdivided into the requirement analyses, the conducted user study and the implementation of our prototype. In the last two sections of this paper, we discuss the results of the conducted user study and findings of our development and evaluation process as well as conclude and give an outlook on our future work, pointing out evaluation steps we are planning in the near future.

2. DEFINITION OF INDIVIDUAL MOBILITY PREFERENCES

Mobility Preferences is composed of the word's "mobility" and "preferences". Preferences can be described as a preference or distinct inclination. When a person has a choice between a number of decisions, preferences play a role in making that decision. Additionally, preferences can be assumed to persist over a period of time because they are preceded by a decision-making process based on sufficient information (Piekenbrock, 2020). Preferences appear, among others, in the field of mobility research, for example, in transportation mode choice. In such studies, participants are asked to express their inclination regarding a particular mode of transport (Knapp, 2015). The term "mobility" should be distinguished from transport. Mobility is divided into potential and realized mobility. The former describes a person's mobility in general. The second is the desire for change of place. The realization of the desire for change of place results in turn in traffic (Becker et al., 1999).

In this work, we repeatedly speak of mobility preferences, which is why a comprehensible definition is indispensable. With the help of the previous information, a combination of mobility and preferences is proposed. If mobility is the desire to change location, mobility preferences can be described as those factors that play a role in the decision to carry out the change of location.

(Loepp and Ziegler, 2014) describe the use of a user profile for intermodal navigation. Their goal is to design an exchangeable user profile that can take into account the specific preferences of the users. With respect to mobility preferences, this is an important step because although they are often mentioned in the context of mobility research, a clear classification is not available. Therefore, the user profile proposed by Loepp and Ziegler is used as a basis for mobility preferences. The user profile consists of three parts: Static Profile Data, Static Preferences, and the Situational Context, see Fig. 1. Static profile data describe fixed data such as age, origin, or transportation mode ownership, which usually rarely change. Static preferences include data that express users' inclination regarding different aspects of navigation. The situational context describes factors that cannot be changed in the short term, such as the weather or the time of day. Furthermore, the situational context has an impact on the static preferences.

In a next step, mobility preferences are derived from the static preferences. They form a set of factors that influence the users' travel planning. However, they need to be considered and explained in more detail for the use case of this thesis. The use case refers to the use of public transport only. The proposed user profile of Loepp and Ziegler is too complex for the mentioned use case and therefore has to be adapted.

3. RELATED WORK

Planning a trip by public transport is an important step that can be time-consuming and nerve-wracking. Finding the right connection is not always easy, especially since personal preferences influence the selection of the most suitable route. To find the most suitable route, the journey planner needs to know the mobility preferences of passengers. However, recording these individual mobility preferences is a time-consuming process.

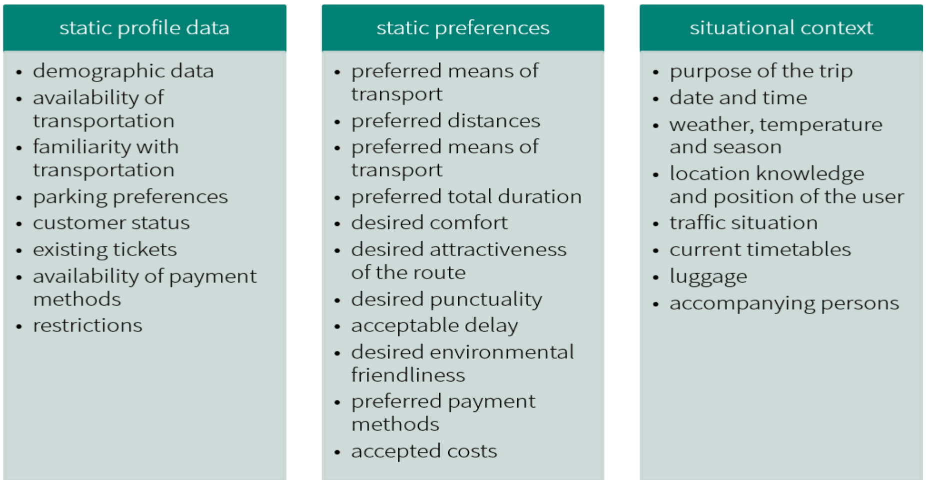

Figure 1. Illustration of the user profile, Loepp and Ziegler (2014).

In their work, (Grotenhuis et al., 2007) investigate what quality of multimodal travel information is required by users and what impact it has on their mode choice. In particular, the different requirements of travel information to the three phases of a trip: Before the trip, at the point of departure, and in the mode of transportation. Before the trip, travel planning takes place. Especially in the area of public transportation, it requires that all necessary information is available so that no further changes have to be made on the way. Information at the point of departure, such as the stop of the train or bus, should only be used for support and not for planning. Information shown on the way in the means of transport also serves as support. For their study of the three phases of travel, they interviewed 191 people, 100 of whom were under 25 and 28 of whom were older than 45. They asked participants about their preferences during the different phases of a trip and what information was important during each phase. Participants could indicate whether they found this information important for different types of information, such as real-time data or duration of the trip. Their results showed that many of the travel information claims are simultaneously necessary for trip planning to occur at all. Information about trip duration, delays, transfers, and departure times are particularly important for trip planning. The ranking of importance was based on how often the respective attribute was selected. The four attributes mentioned were selected by over 80% of respondents.

(Loepp and Ziegler, 2017) conducted an empirical needs analysis focusing on intermodal travel chains. In an initial study, they asked participants about their assessment and use of route planners and journey planner information, among other things. Of the 243 respondents, 103 indicated that trip duration was the most important piece of information. Other important information included real-time data, alternative routes and ease of input. Only 29% of respondents would provide information on their own walking speed. In their second study, they were able to determine with regard to the types of routes that 92% of the 90 respondents, timetable information for unique routes. Furthermore, journey planners are used more for day trips, vacation trips or leisure activities than for commuting or private errands.

In our IP-KOM-ÖV research project, (IP-KOM-ÖV, 2020) is worth mentioning in the context of electronic journey planners. The goal of the project was to increase the quality and efficiency of public transport. One of the work packages includes an interface used for real-time information and was developed within the project. Context, interaction, and classification models were designed to represent the concepts and contexts of public transport.

In our Dynapsis research project (Dynapsis, 2020) is a follow-on project of IP-KOM-ÖV, which aims at connecting passenger information systems and the passenger's daily routine. The user is relieved of the hurdle of mobility planning by having the system consider his schedule and find optimal route suggestions. This can be considered as an approach to automatically calculate a suitable route.

In our currently ongoing SmartMMI research project (SmartMMI, 2022) researcher are focusing on providing information to passengers. The feature of the project is a transparent display to be installed in public transport vehicles. Such a "SmartWindow" supports users with additional and valuable information during the journey. A trip planning or change on the interactive display will be provided. The connection between the SmartWindow and the user's own mobile device is also a relevant feature. While the user is provided with detailed information about the trip on his own end device, the window displays additional, general information.

4. METHODOLOGY

The methodology section summarizes our approach of prototyping an automatic and context-adaptive acquisition method for mobility preferences of passengers in public transport. In the first subsection, the requirement analyses is conducted collecting information about mobility preferences in general. In this phase, we also analyzed the available setting options of selected mobile application used for public transport. Based on the results of the evaluations in first phase, we set up a user study. This user study is described in the second subsection. The results of this user study were incorporated in an interactive prototype. The implementation of this prototype is described in subsection three.

4.1 Requirement Analyses of Mobility Preferences Settings in Mobile Applications

As part of the requirement analyses, we analyzed the setting options for mobility preference available in the six most commonly used German mobile application for public transport travel information. The apps examined contain a variety of setting options, some of which overlap. A comparison of the apps shows that transport mode exclusion can be considered a component of a schedule information app is shown in table 1. The table lists other settings that can be found in the apps, such as transfer time or intermediate stops. "Yes" or "No" means that the apps offer the possibility to make the mentioned setting. For example, in the application, Moovit the walking speed cannot be specified, other than in Öffi where walking speed can be specified as a real value. Relative means that no concrete value can be selected or entered, but only a preference can be expressed. In the case of walking speed, "slow", "normal" or "fast" can be selected. DB's apps allow you to specify a maximum number of transfers, although in the case of DB Navigator this is limited to specifying a direct connection only. Apps that offer a way to optimize the request according to a specific preference, such as "few transfers", can only do this exclusively. Accordingly, it is not possible to optimize for "few transfers" together with "fastest connection" or "shortest walking distance" at the same time. A possible reason for this would be that these specifications are values of the same parameter.

Table 1. Requirement analysis of six commonly used public transport applications in Germany

Parameter	Moovit	Öffi	DB Streckenagent	DB Navigator	Bus&Bahn	KVV.mobil
transportation exclusion	yes	yes	yes	yes	yes	no
walking speed	no	relative	no	no	relative	no
number transfers	relative	relative	absolute	absolute	no	no
transfer time	no	no	absolute	absolute	no	no
accessibility	no	yes	no	no	no	no
bicycle transport	no	no	yes	yes	yes	no
length of footpaths	relative	relative	no	no	relative	no
fastest connection	yes	yes	no	yes	yes	no
stopovers / via’s	no	yes	yes	yes	no	no
special means of transport	yes	no	no	no	no	yes

4.2 User Study using the Contextual Inquiry Method

In order to obtain an initial picture of mobility preferences of public transport users, a series of studies were carried out. The study series consisted of three parts and aimed to observe the users' behavior during trip planning. Based on our previous work identifying mobility pattern from commuters using only mobility data we selected them as the main beneficial user group (Gartner et al., 2021). Participants were given a questionnaire while using a journey planner application on their own smartphone. This has the advantage that users do not feel observed during the study and make possible decisions differently (Patton, 2014).

Our user study is based on the method of contextual inquiry. This has the advantage that users are observed in their actions and then questioned for their motivations Moser, 2013. Since the focus is not a usability test of the journey planner application, no usability expert is brought in to perform these tasks. The observation is done by the application on the smartphone and the questionnaire at the end replaces the interview. The conducted user study aimed to investigate users' decision making in route selection. In addition, a first attempt is made to gain an opinion on mobility preferences. The exact questions are explained in the following chapters. The series of studies is intended to help refute or confirm the theses previously established.

Initially the user study was planned to be conducted in the actual usage context of public transport. Therefore, participants would have to fill out the mobile app questionnaire, for example, when starting their journey on the train. According to the circumstances, scenarios were used here, which were processed by the participants at home. The three scenarios were structured as follows: First: A timed appointments such as meeting for dinner require arriving on time and without worries. The criteria for this are the arrival or travel time as well as the number of transfers. Second: A time-flexible appointments only make demands on a suitable arrival time. Third: the criteria for a journey home are also primarily the number of transfers. As shown in Figure 2, we used the evaluation method of contextual inquiring and therefore developed an in-app questionnaire.

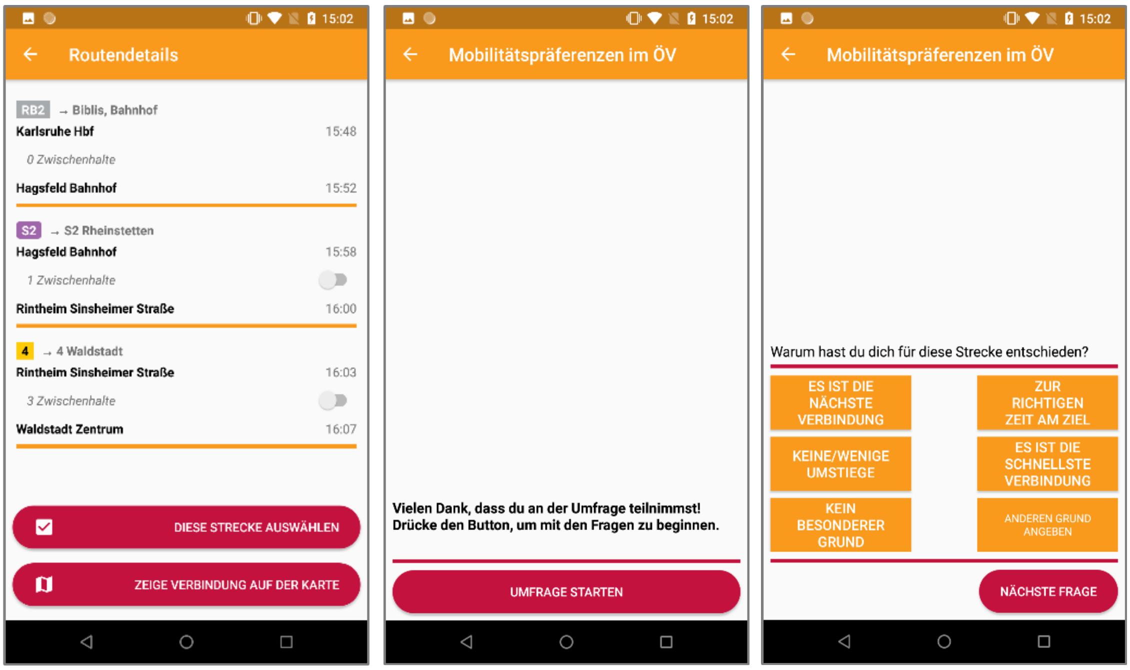

Figure 2. In-App questionnaire evaluating user’s mobility preferences with contextual inquiring method

Our implemented prototype application called “GoEFA” is intended to test some aspects of the concept. The focus is on the passive determination of mobility preferences for the user. Our evaluation showed the four most important mobility preferences are: favored walking speed, favored transportation mode, favored number of changes and favored travel duration. In addition, we have shown a concept how these preferences can be determined by analyzing user's interaction with the smartphone system. In the next step, we applied the gained information by enriching future connection requests.

4.3 Implementation of the User Study

The implementation of the study proved to be problematic, as rail travel was being avoided due to the situation arising from COVID-19 restrictions. Therefore, participants could not be required to use public transportation as initially planned. An alternative option is to use scenarios. Participants were asked to put themselves in the scenario as best as they can. Participants were given a scenario at weekly intervals. The entire study spans three weeks or three scenarios. These scenarios are to be distinguished from scenarios used in the context of user analysis with personas. In (Keller et al., 2019) we prior introduced our public transport personas based on our research projects IP-KOM-ÖV. The scenarios describe the course of a day on which the journey planner is used. The scenarios are based on a time before the pandemic, in which train travel was part of everyday life. Each scenario has a different task. The first scenario is about the visit of a friend. The starting point, destination and arrival time are given and marked in the description of the scenario. For comprehensibility, the dates have been listed again in the document. The second scenario leaves the choice of departure stop and time open. Scenario 3 suggests three departure times: Before an event, shortly after, or much later. The three scenarios are intended to simulate real-life situations in which users can make as many different decisions as possible. In the background, the system also records which routes the users have looked at. The three scenarios used are presented below.

5. RESULTS OF USER STUDY

At the end of the study period, over 20 submissions could be collected and evaluated. An overview over the results is given in the following chapter. Due to the small number of participants in the study, percentage figures were not provided.

As can be seen in Figure 3, the number of transfers has a great relevance in the choice of connections in Scenario 1 and 3. The reason for this may be the nature of the scenarios. In scenario 1, it is required to arrive on time for a set appointment avoiding the other person having to wait. Transferring passengers could result in not being able to reach a connection. In the follow-up question about why the connection with the few transfers is preferred, participants indicated that transfers are stressful and the connection could be missed. In Scenario 3, on the other hand, it may be more important to arrive home reliably and not too late in terms of time. In scenario 2, it is more important to arrive at the destination at the appropriate time. Although an appointment must also be kept, transfers are less relevant, as it is possible to decide for oneself when to travel to the destination. If none of the answer options was applicable, the participants could give another reason. Particularly in scenario 3, it was indicated in the free text field that connections with long-distance traffic are avoided.

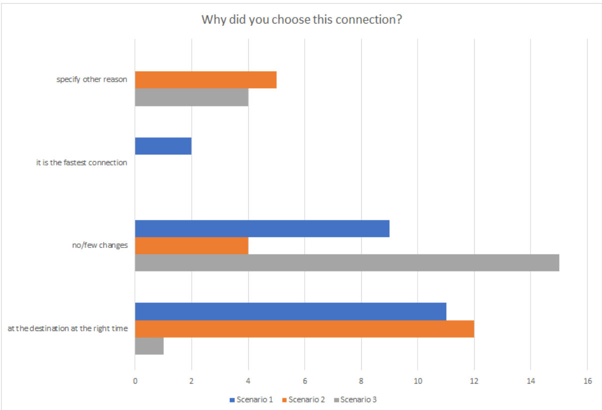

Figure 3. Reasons for choice of a connection

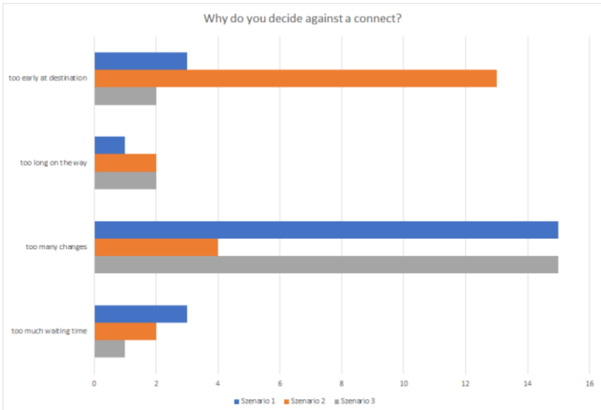

Figure 4. Reasons against choice of a connection

With the second question, a check of the answers from the first question can take place. In Figure 4 can be seen that the answers partially coincide. In scenario 1 and 3, no connections are chosen that have too many transfers. In scenario 2, a large majority indicated that arriving too early at the destination is an exclusion criterion. Travel time and waiting time were only indicated in small numbers.

Figure 5 illustrates that a trade-off is made in the choice of connection. However, how many connections were actually looked at was recorded in the background. The recording shows that ten queries were sent in scenario 1, where only one connection was looked at more closely. In scenarios two and three, there were 14 and 11 respectively. One explanation for the correlation may be that many routes are only looked at more closely if they have transfers. The Figure 6 shows that the common display of connections - descending, with the temporally closest connection first - is preferred. Differences between the scenarios are easy to see, as a certain tendency regarding the prioritization of transfers becomes clear.

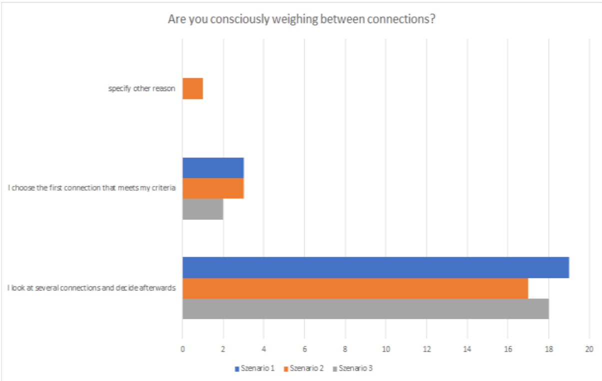

Figure 5. Participants decision weighing

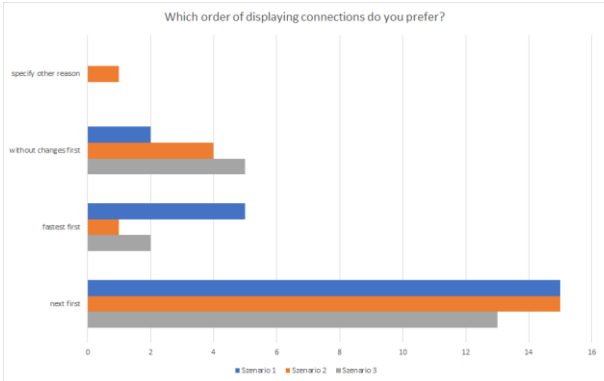

Figure 6. Preference of displayed connections

The answers to the question whether the user would use the option to change the order are available in Figure 7. The purpose of this question is to identify an initial tendency to indicate mobility preferences. The majority of participants indicated that the changeover must be straightforward. The indication that this option is not used decreased from scenario to scenario. A possible explanation could be that participants develop a greater willingness to make this adjustment over the course of the study.

Participants were asked a follow-up question if they indicated that they would not use the option. This again allowed for more specific questions as to why this was the case. The main reason was that the changeover was not needed. Too much effort or fear of doing something wrong was also selected. Due to the small number of responses, however, no reliable statement can be made about a general willingness of users regarding the conversion of settings.

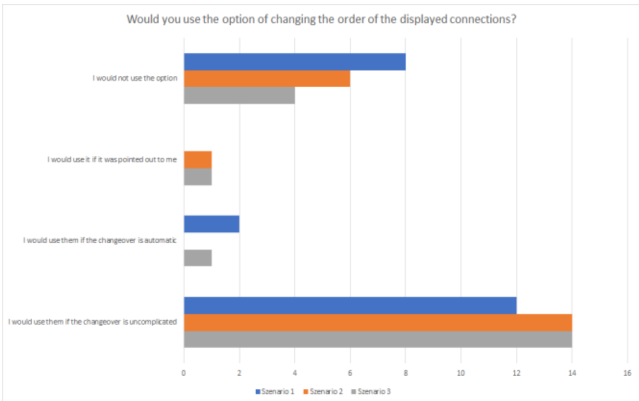

Figure 7. Adaptation preferences of participants

6. CONCLUSION AND FUTURE WORK

In general, our contribution shows the importance and the impact of mobility preferences and describes our analysis and evaluation approaches that we used conducting the user study. We reported on our experiences, the results, the designs of the study we conducted, as well as gave an insight into lessons learned while analyzing user's interaction data. To answer our research question, an in-app user study evaluation using the contextual inquiring method was conducted. Therefore, an in-app questionnaire was formulated to introduce participants to the topic of individual mobility preferences and then ask them directly about their personal mobility preferences. Additionally, the reasons for not stating the individual mobility preferences in mobility application were identified.

The main reason given was not having enough information on the setting, followed by a fear of missing other suitable connections. Some participants indicated that the effort associated with the change would be too great. With the help of these reasons, requirements can be made for possible acquisition methods. The concept includes a preference service that records and validates mobility preferences in the background. This avoids users entering them initially but not updating them later. At the same time, it takes away the effort from users, as well as the fear of setting something incorrectly. A prerequisite for the continuous recording of mobility preferences is an initial measurement. Context is then continuously determined and mobility preferences are created. Future work or future research projects can start here and further investigate mobility preferences.

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