

Join the Ride!

User Requirements and Interface Design Guidelines for a Commuter Carpooling Platform

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Abstract. Carpooling might be a solution for maintaining mobility and reducing traffic problems of cities. In order to exploit the potential of carpooling for congested cities, to enhance the awareness of carpooling platforms among commuters and citizens, and to improve the interaction with existing carpooling web solutions, user-centered research methods (focus groups and usability analysis) were applied to understand the key motivators, acceptance barriers, and design requirements associated with carpooling platforms. The diversity of potential commuter platform users regarding age, gender, carpooling- and Internet expertise was also considered.

Keywords: carpooling, requirement analysis, focus groups, usability analysis, acceptance.

1 Introduction

Maintaining mobility of its residents is one of the key challenges for cities in the 21st century. The high significance of car-related mobility also applies for older drivers because they live in better health conditions which allow them to drive longer, and because they were socialized in the age of the “mobile lifestyle,” in which driving a car stands for independence, freedom, and activity [1].

Due to decreasing numbers of people living in households, the high number of commuters who live in outskirts and want to reach their workplace, and due to the rising number of people living in cities, traffic problems such as congestion (especially during rush hours) and accidents are increasing. Further consequences of these traffic problems are increased traveling time, fuel costs, environmental pollution, and human health effects (e.g., asthma) [2].

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Carpooling might be a solution for the mobility and traffic problems of cities. The concept of carpooling is two or more persons sharing a car trip with the passengers contributing to the driver's expenses and might be a solution for mobility problems of cities by increasing vehicle occupancy [3]. When used as a substitute for a private car, carpooling has the potential to reduce the number of private car owners. Moreover, carpooling might exert effects on mobility behavior [4].

Several web-based carpooling solutions were developed in recent years, enabling potential drivers and passengers to find and arrange shared vehicle journeys. Although carpooling is not a novel concept [5] - first formal carpooling systems were established in the 70ies during the "oil shocks" - the actual usage and awareness of carpooling platforms among commuters in Germany is still quite low. The biggest carpooling platform in Germany ("Mitfahrgelegenheit.de") has more than 4 million registered members with more than 14.000 arranged journeys per day. Other carpooling platforms (e.g., "Mitfahrzentrale," one of the first online carpooling platforms in Germany, founded in 1998) have approx. 800.000 members.

In order to exploit the potential of carpooling for congested cities, to enhance the awareness of carpooling platforms among commuters and citizens, and to improve the interaction with existing carpooling web solutions, user-centered research methods were applied to understand the key motivators, acceptance barriers, and design requirements associated with carpooling platforms. Since the workforce in Western societies is aging due to the demographic change, the diversity of potential commuter platform users regarding age, gender, carpooling- and Internet expertise was also considered.

2 Method

An empirical multi-method approach was applied in order to derive user requirements and interface design guidelines for a commuter carpooling platform.

1. A requirements analysis was conducted using the focus-group approach ($n = 20$), which elicited user requirements for mobility platforms, usage motives, and acceptance barriers.
2. A usability analysis of a web-based carpooling platform was carried out ($n = 50$), which assessed web-navigation performance (effectiveness and efficiency), user satisfaction, sources of usability problems, and allowed to derive design guidelines for web-based carpooling platforms.

2.1 Requirement Analysis

Focus Group Interviews. In order to elicit user requirements for mobility platforms, usage motives, and acceptance barriers, focus group interviews were carried out. Focus groups are a qualitative research method, which are predominantly used in opinion and market research. A selected group of people takes part in an organized group discussion in order to obtain information about opinions and experiences about a

specific topic [6]. The underlying idea of focus groups is that the group interaction helps people to explore and express their opinions during the discussion by exchanging experiences and opinions, commenting on each other, and jointly developing new ideas and concepts.

Procedure. A total of four focus group interviews were carried out. The group composition was age-specific (two focus-groups with younger and two with older participants) in order to give older participants enough opportunity to articulate their wishes and expectations. The focus groups started with a round of introductions and participants were informed about the general goals of our study and about the procedure of the focus group sessions. Also, the interview guideline was presented and participants were asked to answer the screening questions. Applying the brain-writing-method, participants were then asked to write down personal statements regarding requirements, usage motives, and barriers of carpooling platforms on paper cards. Following that, the group of participants discussed their statements about carpooling platform usage. The moderator of the focus groups collected and visualized novel or additional statements.

The Sample. A total of $n = 20$ participants aged between 20 - 70 years took part ($M=35.65$, $SD =14.60$, 40% females). Since the commuter platform was web-based, we asked about Internet experience among the participants. All participants had Internet experience; the majority (85%) used the Internet on a daily basis (10% 2-3x per week, 5% less than once per week). Looking at different usage purposes, 65% used the Internet for online-shopping, 60% for online-banking, 80% for travel bookings, 95% for looking up timetable-information, and 100% for looking up information. According to that, we assume that our participants had at least sufficient Internet experience to be interviewed about web-based carpooling services. Asked about carpooling experience, 40% had at least some experience with web-based carpooling platforms. In order to study the impact of individual user factors, we used the ratings of carpooling experience and Internet experience in order to create two between-factors with the levels low vs. high experience (referred to as “novices” and “experts”).

Data Analysis. Participants’ card statements were collected, transcribed, and categorized. Data was analyzed by nonparametric tests. In order to investigate statistical interactions between user factors and requirements, ANOVAs were applied.

2.2 Usability Analysis

Procedure. A usability analysis of a web-based carpooling platform was conducted which supplemented the findings of the requirement analysis phase. The usability study started with a preliminary interview in which demographic data and computer experience were assessed. Following that, participants had to perform seven experimental tasks,

which represented standard functionalities of carpooling platform usage. The order of tasks was kept constant and was presented in the following sequence:

- Task 1: Free Search for a ride, i.e., finding a driver for a pre-specified trip.
- Task 2: Registration in the carpooling platform as John/Jane Q. Public. All participants received standardized information about personal data for registration (name, telephone number, email-address).
- Task 3: Search for a lift, i.e., finding a driver for a pre-specified trip.
- Task 4: Search for a car passenger for a specified trip.
- Task 5: Placing an add for a lift, i.e., participants had to add additional details about their identity (gender, residency), their car, time and frequency of rides, and preferred car passengers.
- Task 6: Ride costs, i.e., looking up information about travel costs.
- Task 7: Deleting the registration.

After task completion, participants had to fill in a post-questionnaire which assessed users' satisfaction with carpooling system interaction ("1 = very high satisfaction" to "6 = very low satisfaction") and usability problems (on a rating scale with "1 = no problem at all" to "4 = severe problem"), and a follow-up-interview took place.

Participants' web navigation data was logged by using the program Morae®(TechSmith) and the following usability measures were derived according to the ISO norm 9241 [7]. For task effectiveness, the percentage of successfully solved tasks was summed up. As efficiency measure the time needed to process the tasks was measured. Additionally, the perceived ease of use carpooling interface as well as usability problems were surveyed. One test session lasted approx. 1.5-2 hours.

The Sample. In total, 50 participants took part in the usability study. Mean age was $M=45.6$ ($SD= 9.7$) with 47.4 % females and 52.6 % males. In order to study age effects, a between factor "age group" was created with two groups, "younger adults" (aged 18-30) and "older adults" (aged 45-72). Asked about their education, 39.5% reported to have higher education entrance qualifications. Furthermore, 23.7% have the certificate of secondary education, 21.1% the general certificate of secondary education, 13.2% a university degree and 2.6% the advanced technical college entrance qualification. All participants had computer usage experience. The majority of the participants (81.6%) reported to use their computer "daily," 7.9 % use it "2-3 times a week" and 10.5% use the computer "less than once a week". Two thirds of respondents (63.2 %) rate PC usage as "very easy," 23.7 % as "easy," and 13.2 % as "a bit difficult." In comparison, the Internet is used "daily" by 73.7%, "2-3 times a week" by 13.2%, "weekly" by 5.3%, and "less than once a week" by 7.9% of the respondents. Half of the participants (55.3%) perceive Internet usage as "very easy", 36.8 % as "easy", 5.3 % as "a bit difficult" and 2.6 % as "very difficult". Asked about the recent use of carpooling network services, only 7.9% reported having experiences with carpooling services (92.1% do not have experiences). These respondents used carpooling networks far "less than once a week" and were "fairly satisfied" with it. Since the majority of the sample did not have carpooling experience, this factor was not included as a between-factor in statistical data analysis of the usability study.

Data Analysis. Data was analyzed by ANOVAs and t-tests for unrelated samples for interval-scaled data and nonparametric statistics (Mann-Whitney-Test) for ordinal-scaled data; the level of significance was set at $\alpha = 0.05$.

3 Results

3.1 Requirement Analysis

In this section, the results concerning motivators and acceptance barriers of carpooling platform usage, differences in acceptance patterns according to individual factors as well as general requirements for web-based carpooling platforms are presented.

Key motivators of carpooling platform usage were financial motives (fuel cost savings, $M = 5.55$, $SD = 0.61$) in contrast to social (conversations and company in the car, $M = 4.35$; $SD = 0.75$), ecological (ecological consciousness, reducing pollution, $M = 4.20$, $SD = 1.47$), or job-related motives (professional exchange and networking opportunities, $M = 3.05$, $SD = 1.19$) that played a minor role in explaining carpooling acceptance (Fig. 1).

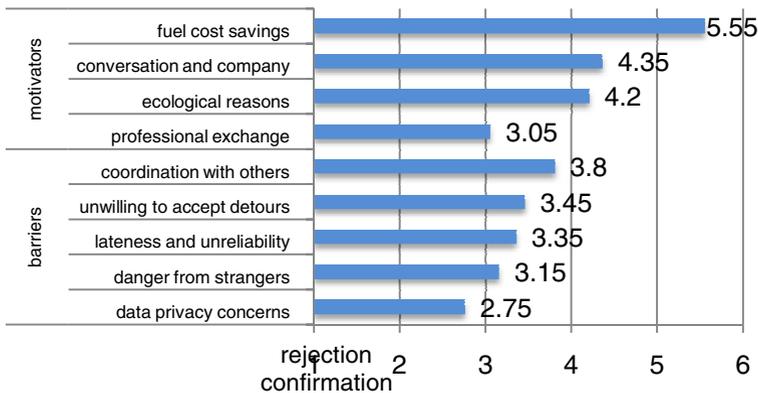


Fig. 1. Key motivators and barriers of carpooling service usage

As *key barriers* to carpooling platform usage we identified flexibility constraints (unwillingness to temporally coordinate with others ($M = 3.8$, $SD = 1.4$) or to accept detours ($M = 3.5$, $SD = 1.4$)). Further barriers such as lateness and unreliability, danger from strangers, and data privacy concerns received average ratings below 3.5, i.e., they were not perceived as barriers to carpooling service usage (Fig. 1).

The inclusion of *user factors* (age, gender, carpooling experience and internet experience) into the analysis revealed insightful differences in user-specific acceptance-patterns: Fuel cost savings were more important for male participants ($M_{\text{male}} = 5.8$, $SD = 0.4$, $M_{\text{female}} = 5.1$, $SD = 0.6$; $F(1,9) = 8.77$, $p < 0.05$), whereas female participants emphasized ecological advantages of carpooling ($M_{\text{male}} = 3.9$, $SD = 1.6$, $M_{\text{female}} = 4.6$, $SD = 1.2$; $F(1,9) = 4.63$, $p < 0.1$). Women also expressed a higher fear of strangers

($M_{\text{male}} = 2.6$, $SD = 0.9$, $M_{\text{female}} = 4$, $SD = 1.5$; $F(1,9) = 7.24$, $p < 0.05$) and higher concerns regarding the exposure of private data ($M_{\text{male}} = 2.3$, $SD = 1.1$, $M_{\text{female}} = 4.5$, $SD = 1.3$; $F(1,9) = 6.81$, $p < 0.05$).

Moreover, ANOVAs revealed interactions between user requirements and interactions. The aspect of saving fuel costs was especially important for young carpooling experts, whereas this aspect was less important for older carpooling experts ($F(1,9) = 6.67$, $p < 0.05$). A similar pattern was found for ecological advantages of carpooling: especially younger carpooling experts perceived ecological advantages as important, but this aspect was far less important for older carpooling experts ($F(1,9) = 11.13$, $p < 0.01$). Regarding carpooling usage barriers we found that especially male participants were not willing to coordinate with others ($F(1,9) = 3.67$, $p < 0.1$) or to accept detours during the ride ($F(1,9) = 3.98$, $p < 0.1$). Interestingly, this finding was moderated by carpooling expertise: Carpooling experts were more flexible in accepting detours ($F(1,9) = 4.69$, $p < 0.1$) and coordination efforts than novices ($F(1,9) = 5.11$, $p < 0.1$).

Apart from motivators and barriers participants also discussed *general requirements* of carpooling platforms. Participants stated the following requirements:

Costs:

- precise definition and high transparency of costs before the trip starts in order to prevent bargaining
- centrally organized invoice-service which issues an invoice about the trips on a monthly basis
- *Information on the carpooling web-interface regarding:*
- trip costs and cost calculation
- tax issues (e.g., tax deduction)
- insurance issues (e.g., liability for car accidents or delays)
- commuter etiquette (e.g., rights and duties of drivers and passengers, what to do in case of delays)
- *Service*
- document download with trip cost calculation information or informed consent regarding “joining the ride at own risk”
- link to route planner applications
- bonus system for frequent commuters
- rating system for friendly/unfriendly drivers
- parking discount or fuel vouchers
- road safety trainings
- more park and ride parking spaces
- *Security*
- personal data security is inevitable
- registration as prerequisite for carpooling service usage
- evaluation profile for carpooling members

To sum up, the requirement analysis revealed main motivators (fuel cost savings) and barriers (lack of flexibility regarding trip time or route coordination) of carpooling platform usage, which are important key levers when it comes to promoting and

carpooling platform usage. Beyond, general expectations of potential carpooling users regarding costs, information, service, and security aspects were identified that should be considered in carpooling service design.

3.2 Usability Analysis

The following section reports users' general performance when interacting with the web-based carpooling platform and focuses on usability problems that were experienced by participants and related to task performance.

Task effectiveness: Participants successfully solved on average $M = 4.2$ ($SD = 1.58$) of six experimental tasks. A minority (2%) was not able to solve at least one task, 16% solved one task, 10% solved two tasks, 8% solved three tasks, five tasks were solved by 28% and 14% managed to solve all tasks successfully.

Task efficiency: Participants needed on average 17 minutes to solve the tasks (range 9 - 42 minutes). In comparison to the benchmark time of 3:31 minutes (when all tasks were consecutively solved by an expert), participants needed on average 14.30 minutes longer for carpooling platform interaction. These performance data results implicate that the interaction with the carpooling platform was neither highly effective nor efficient. This finding is corroborated by users' satisfaction ratings.

Satisfaction: Users' satisfaction was on average 2.57 ($SD = 1.3$), with ratings ranging from 2 - 5. In total, two thirds rated the interaction with the carpooling platform as "satisfying," but one third was not satisfied with the ease of use.

The inclusion of *users' age* revealed that older users achieved a lower task performance and faced significantly higher usability problems when using the carpooling web-interface ($F(2,48) = 5.97$, $p < 0.00$, Fig).

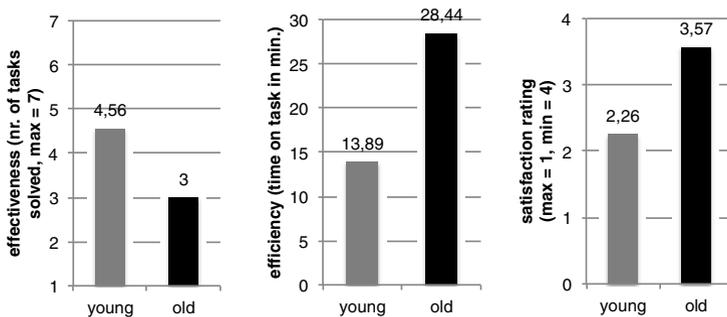


Fig. 2. Task performance (effectiveness and efficiency) and satisfaction ratings for younger and older users

Older users solved fewer tasks successfully ($M = 3.0$, $SD = 2$) in comparison to younger users ($M = 4.6$, $SD = 1.2$; $F(2,48) = 6.17$; $p < 0.05$), needed more time to work with the carpooling interface ($M = 28.44$ min., $SD = 10.00$) than younger users ($M = 13.9$, $SD = 3.3$; $F(2,48) = 37.76$; $p < 0.00$) and reported a lower satisfaction

($M = 3.6$, $SD = 1.3$) compared to younger users ($M = 2.3$, $SD = 1.3$; $F(2.48) = 6.12$; $p < 0.05$). Neither gender differences nor effects of the factor “Internet experience” were found for carpooling system interaction.

Based on users’ experience of *usability problems* during carpooling system interaction, the most dominant usability problem was *navigational disorientation* using the web interface. Users reported that they lost orientation in the hypertext structure of the carpooling system ($M = 3.2$ on a scale with $\max. = 4$, $SD = 0.8$), could not remember the location of specific functions ($M = 2.4$, $SD = 0.7$), had to navigate for a long time until they found the function they searched for ($M = 3$, $SD = 0.7$), and did not to know which navigation path to take within the carpooling system ($M = 3.0$, $SD = 0.9$). The second cluster of usability problems referred to *verbal labeling* issues in the carpooling interface. Users did not immediately understand the meaning of terms ($M = 2.5$, $SD = 0.9$) and perceived the naming of functions as incomprehensible ($M=2.7$, $SD = 0.8$). In contrast, *visual design* problems due to font size ($M = 2.1$, $SD = 0.9$), color ($M = 1.8$, $SD = 0.7$), or design element inconsistencies ($M = 1.8$, $SD = 0.7$) were not perceived to cause usability problems. Correlational analyses proved that task performance (effectiveness and efficiency) and user satisfaction were strongly influenced by disorientation and verbal labeling problems, but not by visual design issues (see Table 1).

Table 1. Bivariate correlations between task performance and satisfaction and usability problem indices ($n = 50$, $** = p < 0.01$)

usability problems	effectiveness (no. of tasks solved)	efficiency (time on task)	satisfaction
disorientation	-.516**	.386**	.537**
verbal labeling	-.523**	0.262	.478**
visual design	0.233	-0.071	-0.072

4 Discussion

Understanding the preferences, attitudes, and user experiences of potential carpooling users is essential for the design and roll-out of successful web-based carpooling platforms which are one important measure in preventing traffic problems and gridlock in present and future urban environments. In the present study, user requirements, usability problems, and interface design guidelines were identified which led to a redesign of an existing web-based commuter carpooling platform. Moreover, the findings provide valuable input for marketing activities promoting carpooling activities.

4.1 User Requirements for Carpooling Platforms

The analysis of user requirements clearly showed that a rather small number of motives are involved in carpooling platform usage motivation. Motivators of carpooling service usage were rated higher than barriers, i.e., our participants were positively

motivated and perceived more arguments for than against the using of a carpooling platform. Especially fuel cost savings were perceived as main advantage of carpooling usage. Accordingly, marketing activities should address this motive and emphasize the potential of fuel cost savings and carpooling platforms should contain a fuel cost savings calculator. The main argument against the use of a carpooling platform is the unwillingness to coordinate with others regarding departure time or trip route.

The requirement analysis also revealed that users distinctly differ in their motive patterns: Older participants reported a lower flexibility to adapt the trip time or route to other passengers' needs. Women put more emphasis on ecological advantages of carpooling platforms, but they expressed a higher fear of strangers and higher concerns regarding the exposure of private data. This shows that data security and privacy are highly sensitive topics in carpooling system design. On the one hand, users expect highest security standards in order to prevent personal data misuse, on the other hand, they also demand a high level of transparency and detailed explanations about which personal data is needed for which purpose.

Further requirements of potential users of carpooling platforms are extensive service functions, such as a cost calculator, an interactive map, a route planner, information regarding legal aspects and insurances. Moreover, potential users expect social media design components, i.e., a "commuter identity and community."

4.2 Usability Barriers and Design Recommendations for Carpooling Platforms

The usability analysis of a web-based carpooling platform showed that the majority of potential users was basically able to use core functionalities such as registration, looking for rides, or placing an add. However, reduced task performance and satisfaction – especially in older users – proved severe usability barriers in carpooling interface design. The assessment of usability problems allowed for an identification of the main causes of reduced system navigation performance.

The biggest usability barrier, navigational *disorientation* in hypertext structures, is a well-known problem [8]. Especially older users or those with restricted spatial abilities feel like getting lost in the hypertext structure and fail to successfully use the interface [9]. In the present study, older users also faced higher usability problems, which led to a reduced effectiveness, efficiency, and satisfaction when using the carpooling platform. Even younger users, who should represent the "best case" of a user group, did not reach perfect performance and satisfaction levels in the interface interaction. For a successful design of carpooling platforms we recommend *transparent search semantics and structures*, which follow the users' mental model. Interviews showed that users think first of trip route and destination (from A to B) when they use the carpooling platform before they think about roles as driver or passenger. Therefore trip offers should not be separated in trip offers and trip requests in the very beginning of the interaction process but the search task procedure should begin with finding and showing compatible trip profiles.

The second cluster of usability problems referred to *verbal labeling* issues. In order to promote a higher transparency of task steps and procedures, precise and clear

verbal labels should be used which indicate the users' current position within a task sequence and within the overall system or hypertext structure. An example of an imprecise verbal label used in the carpooling platform is the link label "what carpoolers helps," which leads to information for calculating trip costs. Accordingly, verbal labels should be short, informative, and with keyword character in order to improve comprehensibility and system transparency.

The third usability barrier was related to *visual design factors*, which had – in comparison to the aforementioned barriers - less impact on carpooling system performance and satisfaction. One important factor is the spatial arrangement or coding of icons and buttons on the interface. When a user looks at a webpage, he/she not only perceives and encodes the content, but also the location of information or control elements on the webpage. When the user is searching for specific information, the user will assume to find similar information (e.g., horizontal or vertical arrangement of entry fields for route starting points and destination) at similar positions. In order to promote the recognition of information or control elements, the spatial location should remain constant. Further visual design aspects referred to animated banners and the use of colors, as especially older users reported a visual overload.

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