How Did You Like This Ride? An Analysis of User Preferences in Ridesharing Assignments

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Keywords: User Preferences, Ridesharing, Assignment, Shared Mobility, Platform Economy.

Abstract: Ridesharing can significantly reduce individual passenger transport and thus greenhouse gas emissions generated by traffic. Although ridesharing offers great potential, it is not yet popular enough to be seen as an important contribution to solving the aforementioned problems. Our hypothesis suggests that we need to make the assignment mechanism of ridesharing systems more human-centric and comprehensible in order to popularise ridesharing. Therefore, we investigate factors that influence the choice of users and their satisfaction with the assigned ride. Most of today's ridesharing assignment algorithms focus solely on features such as time, distance, and price. Contrary in this paper, we examine additional factors that influence customer decisions to increase their satisfaction. Therefore, we first conduct a literature study to identify previous preferences relevant for ridesharing from a research perspective. Subsequently, we extract the relevant preferences for an assignment process. From these we secondly conduct a survey. Last, we analyse the obtained survey data and order the preferences based on their importance for participants overall and among demographic subgroups.

1 INTRODUCTION

The impact of increasing greenhouse gas emissions on our environment has been scientifically proven (Parmesan and Yohe, 2003) and we are facing the fastest global warming phase since the beginning of the weather records. One of the most significant contributors to emissions is the individualized transportation of people, mostly through personal vehicles. By sharing personal vehicles with other travellers (i.e. ridesharing), better vehicle utilization can lead to substantial fuel savings and reduced emissions (Jacobson and King, 2009). Scholars have researched the acceptance of ridesharing for decades; nonetheless, there are still factors that limit a widespread adoption of ridesharing, including pricing, high-dimensional assignment, trust, and reputation, as well as institutional design of such services (Furuhata et al., 2013). One of the fundamental challenge in ridesharing is to bring driver (supply) and riders (demand) together. Therefore, a market mechanism is necessary to enable ridesharing services on a larger scale. Advancements in information technologies (IT) enabled new information systems (IS) in form of web platforms with assignment facilities for supply and demand. However, to be successful, the chicken-and-egg problem inherent to these platforms has to be overcome, namely suitable rides offered and demanded. Conceptually, these platforms have two phases: First, users announce their ride offerings and requests, and second, these offerings and requests are assigned. Since the assignment is the core activity of the ridesharing IS platform, it is of particular interest to understand if users perceive the assignment as satisfactory. In this paper, we understand ridesharing as at least two individuals sharing a common ride in the same vehicle.

Furthermore, we consider the assignment process as bringing two individuals together based on certain criteria like a route, price or the consideration of users preferences for a trip. This can also contain the allo-

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cation of vehicles. On a larger scale, the assignments process can become a multi-dimensional optimization problem, as multiple configurations may be possible to assign drivers and riders.

In principle, assignments in ridesharing can be accomplished in two ways: First, the provider could do the assignment according to its own discretion. From a user perspective, such assignments happen "as is", in a non-transparent fashion. User needs may or may not be reflected by the assignment, potentially rendering users dissatisfied. Second, the provider could do the assignment in a transparent way, allowing users to understand the assignment. Furthermore, user preferences and needs may be prompted in advance and influence the assignment to maximize the joint satisfaction of a driver and the according rider(s). To align such user preferences on a large scale in an automated and flexible way, artificial intelligence (AI) technologies may be helpful. Nonetheless, to feed such AI, it is necessary to understand, which user preferences exist that influence a user's satisfaction with the ridesharing assignment. In current research, such assignment preferences are only addressed in limited amount. For example, (Bian and Liu, 2019), (Neoh et al., 2018), (Yousaf et al., 2014) and (Chaube et al., 2010) considers only a handful of individual preference factors such as price and social relations of travelers that influence personal satisfaction with ridesharing experience. To the best of our knowledge, none of the present studies have reviewed a great number of factors to provide insight into the satisfaction function of users within ridesharing assignment processes. Therefore, our study considers several factors simultaneously, leading to our main research questions:

- *Which preferences influencing ridesharing users prevail in the literature?*
- *Which preferences influence a users' satisfaction within the assignment process of ridesharing?*
- *Does this preferences' order by importance differ for subsets of people who vary in age, gender, country, etc.?*

In this study, we firstly provide the research background in Section 2 and describe the methods in Section 3 used in this paper to enable more human-centric assignments in ridesharing. We perform a literature study in Section 4 to extract preferences and conduct an online questionnaire with more than 290 participants to investigate their relevance. The results of the latter include an order of preferences overall and in groups based on demographics. Those are described in Section 5 and combined with the findings from the literature study in Section 6. Finally, we conclude our overall contributions in Section 7.

2 RESEARCH BACKGROUND

Ridesharing Terms. In this study's context, we define ridesharing as "the formal or informal sharing of rides between drivers and passengers with similar origin-destination pairings" (Shared and Digital Mobility Committee, 2018). Within this definitory framework, multiple archetypes of ridesharing are conceivable, from employees commuting together to ridesharing as a service solutions providing on-demand and door-to-door ride services. Historically, during the Second World War the first organized ridesharing was implemented by the U.S. government as a regulation to save fuel (Furuhata et al., 2013). Later as a result of the oil crisis several ridesharing methods emerged in the 1970s. Afterwards, the popularity of ridesharing decreased due to more complex travel patterns caused by demographic changes (Ferguson, 1997). Then, with the rise of the internet ridesharing services that assign riders and drivers became apparent (Furuhata et al., 2013) and with technological advancements like GPS-enabled smartphones dynamic ridesharing services such as UberPool became possible. Dynamic services let users offer rides as a driver or request rides as a passenger at any time (Nourinejad and Roorda, 2016). Nowadays, ridesharing offers economic, environmental, and social benefits by reducing the number of vehicles and travel cost (Neoh et al., 2018).

Human-Centric Assignment in Ridesharing. Despite the increasing traffic in cities and the potential of ridesharing to reduce the pollution caused by traffic, particularly in Germany ridesharing is not very popular (Statistisches Bundesamt, 2019). Previous literature indicates that one reason for this reluctance lies in the assignments. In order to design a shared ride in such a way that travellers need to make minimal effort, a system should automate the assignment to satisfy the customer's needs (Agatz et al., 2012). However, this deliberation appears to be easier to implement than it is in practice. The configuration of a selection-based assignment process is not trivial (Washbrook et al., 2006). Nowadays, most business models only consider the desired route and price in their assignment engine. Other factors, including personal preferences such as comfort or safety of the vehicle, receive none or limited attention. Nevertheless, we argue that more personalized assignments can increase the popularity of ridesharing and, thus, its actual use. Research has shown that riders only feel comfortable if they are assigned to a ride with a spe-

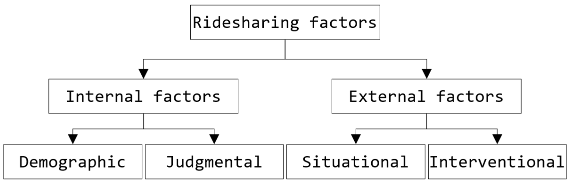

Figure 1: Categorization of ridesharing factors (Neoh et al., 2018)

cific group of people, and that the group's preferences may be motivated by personal safety or social aspects (Agatz et al., 2012). At nighttime, for example, a shy person may not be willing to share a trip with a complete stranger and may only want to share trips with friends and colleagues. Clearly, the more restrictions a potential user imposes on his pool of potential ride companions, the more difficult it will be to find successful assignments for that user (Dailey et al., 1999).

Systematisation of Preference Factors. To date, few studies have focused on user preferences in ridesharing. Instead, many studies include some preference factors, but rather as a supplement to their primary study design. To reach a unified systematisation of the influence individual decisions to share rides, (Neoh et al., 2017) has developed a categorisation model shown in Figure 1. On the first level, influencing factors are differentiated between external and internal factors. On the second level, internal factors are separated into socio-demographic and judgmental factors such as users' reasons to share rides (Neoh et al., 2017). Previous studies assume that demographic factors have only a very small impact (Vanoutrive et al., 2012) while—in combination with other factors—they may have an influence (Correia and Viegas, 2011). While, under the group of judgmental factors, all psychological factors like social aspects and feeling of independence while driving the own car are considered (Neoh et al., 2018). On the contrary, external factors include situational factors and interventions and take place at the environmental level of the ridesharing user (Neoh et al., 2017). Thereby, situational factors affect the location as well as all waiting times such as waiting time for other passengers. Usually it makes ridesharing less attractive when one or more of these factors lead to long journeys (Tsao and Lin, 1999). In contrast, interventional factors like mediating actions that are implemented by a facilitator, e.g. a facility which encourage people to share rides through a parking discount but also partner assignment systems belong to this category. Studies lean to say penalising single occupied vehicles are more effective than rewards for ridesharing (Neoh et al., 2018).

3 METHOD

To identify relevant preferences for assignments in ridesharing, we first review current literature. We decided to conduct a survey afterwards, because it is an effective and popular method for gathering information about people. Next, the process of gathering the literature, the design of the study, and relevant data analysis techniques are described.

3.1 Literature Study

To systematically review existing research in the area of ridesharing preference factors, we followed a literature review process based on (Webster and Watson, 2002) and (vom Brocke et al., 2009). Therefore, we first gathered literature from IS journals and conferences as well as general databases to include transportation outlets by a generalized search string. Second, we identified the mentioned factors in each article and third, we summarized these factors with regard to their commonness.

To find relevant literature a search query was created in phase three, using the term ridesharing and possible synonyms: *ride sharing*, *ridesharing*, *ride pooling*, *ridepooling*, *car pooling*, or *carpooling*. This was used to search the most popular IS journals (basket of eight), the ten mostly cited transportation journals according to the scientific journal ranking (SJR) and the IS conferences. The search was limited to literature published between 2015 and 2019. The search query had to be found in the title or abstract of the literature. Afterwards, the left articles are read and relevant preferences are selected.

3.2 Empirical Study

Overall, we conducted a questionnaire consisting of 68 questions, which were provided in English and German. Two of the questions are for attention checks to enable a high-data quality; one is an open question enabling users to provide preferences, we did not consider. Besides that, the questionnaire consists of four parts: 1. Present and future usage of ridesharing (6 questions); 2. Preferences of passengers (41 questions); 3. Information for a ridematching algorithm (10 questions); 4. Demographic data (8 questions).

Because five-point Likert scales are typical (Sullivan and Artino, 2013), we used such for the second and third part. We prefer Likert scale questions over a conjoint analysis, because we did not expect a large number of participants and the number of preferences to investigate is relatively high. For every question the participants had the option to provide no answer.

The questionnaire does not contain any condition excluding any questions and was provided online to enable fast conducting around the world and reducing cost. The downside of enabling easy access is, that we were not able to observe preferences like *trust* objectively via an observation. We used LimeSurvey (see (Schmitz and Team, 2012)) to create and host the questionnaire. We shared the questionnaire via email-lists of our universities and among our social networks. The data is stored anonymously and there were no incentives to participate. All questions and the structure is available in an online repository[1].

3.3 Techniques for Analysis

Order preferences by importance. Our approach to create an order of preferences by importance is threefolded:

- Firstly, to get to an initial order of importance for the preferences, we transform the answers to numeric values with similar distance and sum up all answers for each preference. The comparison of these sums leads to an initial ordering.
- Secondly, we limit the preferences for further analysis to later be able to verify the order statistically in the third step and focus on the relevant results. For the limitation, we apply hierarchical agglomerative clustering to cluster the preferences. We favor this technique over partitioning, like k-means, because thereby, we use a deterministic algorithm and we do not have to choose a number of clusters in the first place. As concrete algorithm, we chose the Ward's method.
- Thirdly, we apply a Friedman test to get a statistically verified order of preferences to the first and second cluster. We apply this test to compare all left preferences importances against each other. For this procedure we orientate on (Derrac et al., 2011), who describe among other things the $N \times N$ comparison of algorithms performances. As post-hoc procedure we choose Shaffer's method. Based on the resulting p-values (p) we construct the order. We set the significance level α to 0.01 to cover all common significance levels.

Importance Order in Demographic Groups. In this part of the analysis we split the valid samples into subgroups based on the collected demographic data and again create an order based on the importance of preferences. Thereby, we are able to identify differences between subgroups. We consider subgroups that appear at least 21 times in the data. To statistically verify differences between subgroups, we apply a Mann-Whitney rank test (see (Mann and Whitney, 1947)). We favor such over the Wilcoxon signed-rank test, because the compared groups are independent. Similar to before we set α to 0.01.

Software. For the Wilcoxon signed-rank, the Mann-Whitney rank test, and clustering of preferences we use the implementation provided by (Jones et al., 2001). The complete source code used for our analysis in Section 5 is available online in a repository[1].

4 PREFERENCE ANALYSIS - LITERATURE OVERVIEW

The method described in Section 3.1 results in 63 relevant articles. The detailed results can be found in our online repository[1]. After having analysed the final sample, based on the 63 articles, 73 factors impacting human attitude towards ridesharing were determined. These factors were categorized in the categories recommended by (Neoh et al., 2017). To make concise comparisons between categories, factors of similar nature were merged into subcategories leading to the overview presented in Table 1.

4.1 Selection of Preferences for our Survey

Based on the results of the literature review we selected the preference factors that were assessed though a survey. Thereby, we limited the scope so the participants could clearly understand the setting of the study. The literature review had resulted in a wide scope of preferences, of which not all are plausible in the context of assignment. Hence, we decided to focus on factors influencing the individual judgement and, in turn, the actual behavior: to share a ride or not. This leads to focus on the preferences of the passengers and excludes preferences of the driver. Besides, we only include factors that are relevant for assignments when a user has already overcome the first barrier of using ridesharing. Therefore, preferences such as peer pressure or living in rural areas are excluded. Privacy is only included indirectly, because when a person has decided to participate in ridesharing, we assume that this person is already willing to give up his/her privacy to a certain degree. Going along with the categorisation of (Neoh et al., 2017), we mainly consider *judgemental factors*, as well as some *situational factors*. Demographic factors are surveyed separately in the last part of the survey, while interventional factors are not considered as they refer to

[1] https://gitlab.tu-clausthal.de/ss16/questionnaire-analysis-public/

Table 1: Overview of preference factors from literature

Demographic	**%**	**Judgemental**	**%**	**Situational**	**%**	**Interventional**	**%**
gender	7.9	economic benefits	84.1	time related	61.9	HOVL	28.6
education	7.9	ESB	77.8	flexibility	28.6	parking space	20.6
age	6.3	convenience	61.9	availability	15.9	parking fee	15.9
ethnicity	6.3	privacy	36.5	meeting point	9.5		
income	6.3	safety	22.2	finding rides	7.9		
employment type	3.2	trust	19.0	living location	6.3		
sexuality	1.6	security	17.5				
peer/family pressure	1.6	pleasure	11.1				

third-party interventions that play an superior role in ridesharing, but do not affect the assignment process.

Based on the results of our literature review, we derived the list of preferences shown in Table 2 to be considered in the survey. The table describes all judgemental and situational factors as well as the surveyed preferences of these. To easier identify the factor of a preference, we introduce an abbreviation of the factor, which will be used in later graphics. In the following subsections, the judgemental and situational factors are outlined in greater detail.

4.2 Judgemental Factors

This category refers to internal and judgemental factors of ridesharing users, which include the judgement of *economic benefits*, *environmental* and *social benefits*, *convenience*, *privacy* and *safety concerns*, *trust*, *security*, and *pleasure* in ridesharing opportunities.

Economical Benefits. The most prevalent factors in regarded research are the ones that are economically or environmental and social beneficial for drivers and passengers. *Economically beneficial factors* like reduced cost are referenced in 53 articles of the reviewed literature. The fact that ridesharing can reduce the travel cost is the most stated factor in the analysed literature, being mentioned 48 times. While ridesharing services can operate at a lower cost compared to traditional taxi organisations (Schweitzer and Brendel, 2018), private ridesharing can reduce the travel cost by splitting it up between driver and passengers (Wang et al., 2018). Besides, saving fuel was indicated as a factor 21 times. Because this also saves money and therefore is economically beneficial (Mourad et al., 2019), saving fuel belongs to this category. Besides, saving fuel also is environmental beneficial (Li et al., 2017).

Environmental/Social Benefits. Overall, ridesharing does offer *environmental and social benefits (ESB)*, which are common benefits that all parties profit from like reducing the instances of drunk driving (Greenwood and Wattal, 2017). Environmental benefits like reducing the overall energy waste or increasing sustainability can also be of altruistic nature (Wang et al., 2019). Saving CO_2 emissions (Li et al., 2017) and reducing congestion (Mahmoudi and Zhou, 2016) can be achieved, because ridesharing increases the utilization of a vehicle's capacity (Lavieri and Bhat, 2019a). This in turn saves fuel and therefore ridesharing can play a certain role in reducing overall energy consumption (Wang et al., 2019). The fact ridesharing reduces traffic congestion was mentioned in 30 of the analysed articles. Ridesharing can significantly reduce the number of cars on the road and therefore limit traffic congestion (Stiglic et al., 2015). Ridesharing also reduces car ownership because it serves as a convenient and cost efficient alternative to owning a car without the financial and social burdens of ownership (Liu et al., 2017).

Convenience. Factors that impact the *convenience* of ridesharing are referenced in 39 of the reviewed articles. Convenience is a factor that can positively or negatively impact human attitude towards ridesharing, depending on which kind of transportation it is compared to. Compared to driving with a private car, ridesharing is perceived as rather inconvenient (Xiao et al., 2016). However, in the reviewed literature it was also stated, that ridesharing can offer the convenience of a private car while paying a similar amount as for public transportation (Sánchez et al., 2016; Nielsen et al., 2015; Wang et al., 2019). Further factors supporting ridesharing convenience are availability of different payment methods for ridesharing-services (Hong, 2017), the ease of use of these services (Greenwood and Wattal, 2017), avoiding transfers (Yan et al., 2019) and reducing driver stress (Mahmoudi and Zhou, 2016). Service quality, which can also benefit the convenience of ridesharing, was only named twice in the present literature. Moreover, clear policies can reduce the concerns about service surcharges (Zhang et al., 2018), the condition of the car (Mirsadikov et al., 2016) and options like non-smoking vehicles benefit the comfort of the ride.

Privacy, Safety, and Security. Other factors re-

Table 2: Overview of preference factors in survey

Judgemental factors	**Preferences**
economic benefits (ECB)	paid *price*
environmental/social benefits (ESB)	vehicle *congestion* and *power*
convenience (CON)	*payment method*, short *breaks during ride* on longer journeys (longer than two hours), mainly *motorway usage* or *rural road usage*, *short duration* of journey, *pets allowed* in vehicle
privacy	indirect
safety (SAF)	*driver's competence*, previously *information about driver*, *calm driving* or *sporty driving* style, *track location* for security, *safety* and *condition* of the vehicle
trust (TRU)	*trust* in other people
security (SEC)	*no trip cancelling* from the driver, *saying no if cancel* of trip, *insurance* of passengers during the ride
pleasure (PLE)	small number of fellow passenger (*low occupied*), *smoking* while driving (whether desired or undesired), *friendliness* of other people, *temperature* in the vehicle, *interpersonal climate*, *volume of music* (including no music), *type of music*, and *conversation topics* during the journey, *similar interests* of passengers, trips pass on *sightseeing* locations, *smell* in and *cleanliness* of the vehicle, amount of *space on seat*, *space in trunk*, existence of *air conditioning*, *comfort* of the vehicle
Situational factors	**Preferences**
time related (TIR)	*low delay at start* and *low delay by pickup* of other passengers (both less than 10 minutes), *short distance*
flexibility (FLE)	drivers *respondance to wishes* of passengers
availability/accessibility	not relevant for assignment
meeting point (MEP)	*small detours* to be collected or dropped off
finding rides/ high assignment rate	not relevant for assignment
living location	not relevant for assignment

garding perceived ridesharing risks include *privacy-*, *safety-* or *security*-concerns. The perceived privacy risk is referenced an utmost barrier in ridesharing (Xiao et al., 2016). It is shown that privacy sensitive individuals are less likely to have experience in using ridesharing services (Lavieri and Bhat, 2019b). Privacy concerns mostly are about the intentional misuse or disclosure of private data to third parties, which is required for using ridesharing services, like credit card information or the users living location (Hong, 2017). In recent literature the loss of privacy is often seen as a trade-off for the financial benefits that come with ridesharing (Tian et al., 2019). Individuals using ridesharing are also faced with safety concerns and security risks: It is indicated that travellers are hesitant about being in a vehicle with unfamiliar people (Lavieri and Bhat, 2019a). The passenger could be worried about getting kidnapped or attacked, while drivers could be concerned with riders damaging their car (Mirsadikov et al., 2016). As a resolution a concept is proposed using meeting points to preserve the users privacy and security (Aïvodji et al., 2016). In this approach ridesharing users do not share their starting point or destination and therefore mobility traces related to users cannot be linked.

Trust. Such factors are referenced in 12 of the analysed articles. For example, existing commercial driver's license can have a positive influence on users attitude towards ridesharing (Hong, 2017). Besides, driver screening and tracking systems as well as rating systems give users of ridesharing services a feeling of safety. A rating system, for both drivers and riders, is an additional factor that can build trust. For riders a rating system can show them what service quality they can expect and it also is a safety and security measure (Mirsadikov et al., 2016). However, a rating system can be exploited by riders and used as a lever to manipulate drivers into providing extra services, because drivers often will be excluded from a ridesharing-service if their ratings are too low (Mirsadikov et al., 2016).

Pleasure. Under the term *pleasure*, we summarize all mellow factors mentioned in the literature which have an influence on the positive/negative state of mind of the user. The number of passengers, for example, is an indicator associated with social inconvenience and positive social interactions. Expected social discomfort or awkwardness is one of the negative perceptions that individuals have about riding (Nielsen et al., 2015). But ridesharing is not only seen as socially unpleasant, but also as an opportunity for positive social interactions such as fun or emotional pleasure by making friends and learning new knowledge (Wang et al., 2019). A variety of factors, such as the desire for diversity, the desire to meet with strangers, or the equipment in the car with telephone chargers or water (Mirsadikov et al., 2016) can influence the person's opinion of ridesharing opportunities and the possible enjoyment and pleasure of a ride (Lavieri and Bhat, 2019b).

4.3 Situational Factors

The third category refers to factors which are external and mostly location-based (Neoh et al., 2017). The location can influence the travel distance, travel time and the likelihood to find ridesharing partners (Neoh et al., 2018). Therefore, we derived factors that are *time-related*, concern the *flexibility* or *availability/accessibility*, refer to the *meeting point* or the *rate of finding a ride* or the *living location*.

Time Related Preferences. The reviewed literature reveals, with *time related factors* being the most mentioned situational factors (39 times mentioned), that users seem to be time sensitive when it comes to ridesharing. Waiting times are perceived as inconvenient by ridesharing users (Sánchez et al., 2016; Stiglic et al., 2015), however waiting at a meeting point as a group may facilitate the safety perception of riders (Stiglic et al., 2015).

Meeting Points. The ability to choose a *pick-up and drop-off location* can offer some degree of anonymity and safety for the rider when using a ridesharing service, because it provides the option to not share personal information like the individuals living location (Mirsadikov et al., 2016).

Availability/Accessibility. The distance to a meeting point can also be linked to the *availability of ridesharing*, which was mentioned 7 times as well as to the individual's *living location*. Existing information technology is an underlying prerequisite and cellular phone service is mandatory for most ridesharing services to work (Joseph, 2018). The availability of ridesharing also influences the *assignment rate on ridesharing services*, since a higher availability implies an increased amount of people using ridesharing in an area. A high assignment rate is a critical success factor for a ridesharing-service, because only successfully matched users will have a positive experience and promote the service to others (Stiglic et al., 2015).

Flexibility. 18 articles mentioned *flexibility* as a factor that influences people in using ridesharing. Ridesharing services can provide increased flexibility compared to taxi services such as types of vehicles and pricing prior to the trip (Joseph, 2018). However, this cannot offer the same flexibility as an owned car (Schweitzer and Brendel, 2018). This indicates that passengers of public transportation like train or bus are more likely to substitute with ridesharing than drivers that own cars (Schweitzer and Brendel, 2018).

5 ANALYSIS AND RESULTS OF SURVEY

In the first paragraph of this section, we make our process of cleaning the data based on attention checks transparent. After that, we list the characteristics of the collected sample. Then, we show our analysis results of our observed overall order of preferences and the differences in demographic subgroups. For the second, we list results for *age*, *gender*, *education*, and *country of residence* in separate paragraphs. Afterwards, results for *working status*, *car owners*, and *pet owners* are summarized in one paragraph.

Clearing of the Dataset. We exclude 17 samples from the analysis, because they did not understand the given definition of ridesharing, failed an attention check, or answered less than 25 percent of the questions. This results in 291 valid samples. For further analysis we also extract the *preferences of the passenger part* from the questionnaire and replace the text-based answers (*important*, *rather important*, *neutral*, *rather unimportant*, *unimportant*) by numeric values (1, 2, 3, 4, 5).

Sample Characteristic. The 291 participants completed the questionnaire on average in nine minutes. On mean the people were 29 years old with a standard deviation of 12. 135 of the participants where female, 149 male, and seven reported no gender. Most of them come from Germany (242), 23 from Israel, two from the Netherlands and China each; from France, Hungary, Senegal, Spain, and Turkey we had one participant each. Moreover, 17 people did not provide their country of residence. The data points where collected from August to October 2019.

Overall Importances. To initially order the preferences by their importance we apply a simple approach: We sum the values of all data points for one preference and compare this with the others. The smaller its sum, the more important a preference is. Together with the proportions of answers, this order is shown in Figure 2. This is combined with Ward's method for clustering of the preferences (not the people), which results in four clusters shown as colors and with a dendrogram above. The fact that the clusters do not disrupt this initial order of the preferences is remarkable.

Together, both approaches already give a good idea about the relative importance of the preferences. Nevertheless, this result has to be interpreted with care, because for its creation for instance *important* has five times more influence than *unimportant*.

Therefore, we further apply a Friedman test with Shaffer's correction method to the first (green) and second (black) cluster. We excluded the third (blue) and fourth (red) cluster to be computationally able to apply the test and focus on the relevant results. The resulting groups of the test are included in Figure 3 in the labels of the x-axis. The concrete p-values of the Friedman test are shown in a heatmap available in our online repository[1].

The result clearly shows that *no trip cancelling* is in group (a) based on the Friedman test results and therefore the most important preference. Afterwards, we have a group of *say no if cancel*, *safety*, *driver's competence*, and *smell*, which slightly overlaps with group (c). In contrast to the order by the simple approach, *short duration* and *low delay by pickups* appear between the preferences currently on sixth and seventh position. Overall, it is hard to provide a clear order, besides the groups heavily interfere. Nevertheless, the groups can be used more clearly to provide $1 \times N$ comparisons. This shows for instance, that *comfort* is less important than all preferences before *friendliness* and *low delay at pickup*.

Importances in Demographic Groups. The orders for *age* and other demographic subgroups are shown in Figure 3 and computed with the simple approach. On the y-axis the condition for each subset is listed together with the number of samples matching this condition; the x-axis lists all preferences. Each cell of the matrix contains the calculated rank for a subset/preference combination based on the simple approach. The colors represent the sum used to calculate the importance order divided by the sum for all answers of the considered preference. After naming the subgroups, we summarize in the following the statistical differences among them.

Age. Concerning the *age* of participants, firstly we create three subgroups: younger than 21, from 21 to 35, and older than 35 years. We observe, that *insurance*, *calm driving*, *volume of music*, *breaks during ride*, and *congestions* are more important for people older than 35 compared to the middle aged group. On the opposite, people between 21 and 35 care more about a *friendliness* and *price*. Compared to people older than 35, *trust* and *friendliness* are more weighty for people younger than 21. On the opposite, *calm driving*, *space in trunk*, and *volume of music* matter more for the middle aged group. Comparing people between 21 to 35 to people younger than 21 shows, that only space in trunk matters more. In contrast, *insurance*, *track location*, and *congestion* are more important for the youngest group.

Genders. Distinguishing between *genders* shows that for women *information about driver*, *trust*, *respondance to wishes*, *tracking location*, and *congestions* are more important for women.

Education. To compare certain levels of *education*, we consider four subgroups: Matriculation standard, bachelor or master degree, and doctorates. Compared to people holding a matriculation standard, for people with a bachelor *information about driver* and *friendliness* are less important. Relative to master degree holders, people with matriculation standard care less about time (*short duration*, *motorway usage*), *space in trunk*, and *air conditioning*. However, *sporty driving*, *insurance*, and *track location* is more important for them. Compared to people with a matriculation standard, for doctorates *smoking*, *low occupied*, and *motorway usage* are more important. On the other hand *friendliness* is more important for people holding a matriculation standard or master degree. Comparing doctorates with bachelor degree holders shows that *smoking* and *calm driving* is more important for the former.

Country of Residence. Comparing the importance of preferences for Germans with the small number of Israelis, shows that *say no if cancel*, *safety*, *condition*, and *friendliness* is more important for German residents. On the opposite, *temperature*, *air conditioning*, *sightseeing*, *low delay at start*, and *smoking* are more important for Israeli residents. In contrast to all other subgroups, for Israeli residents *smoking* is most important. Moreover, *say no if cancel*, *safety*, and *driver's competence*, which are among the top five for all other subgroups, are relatively unimportant.

Left Subgroups. When comparing students with employed people, we observe that *no trip canceling* of a trip is more important for employed people. On the other hand, students seem to care more about *insurance* and *track location* during the ride. We were not able to verify a difference between car owners and those who do not own a car; similarly there was no influence by owning a pet. For smokers *condition*, *cleanliness*, and *power* are more important; for nonsmokers *smoking* is more important.

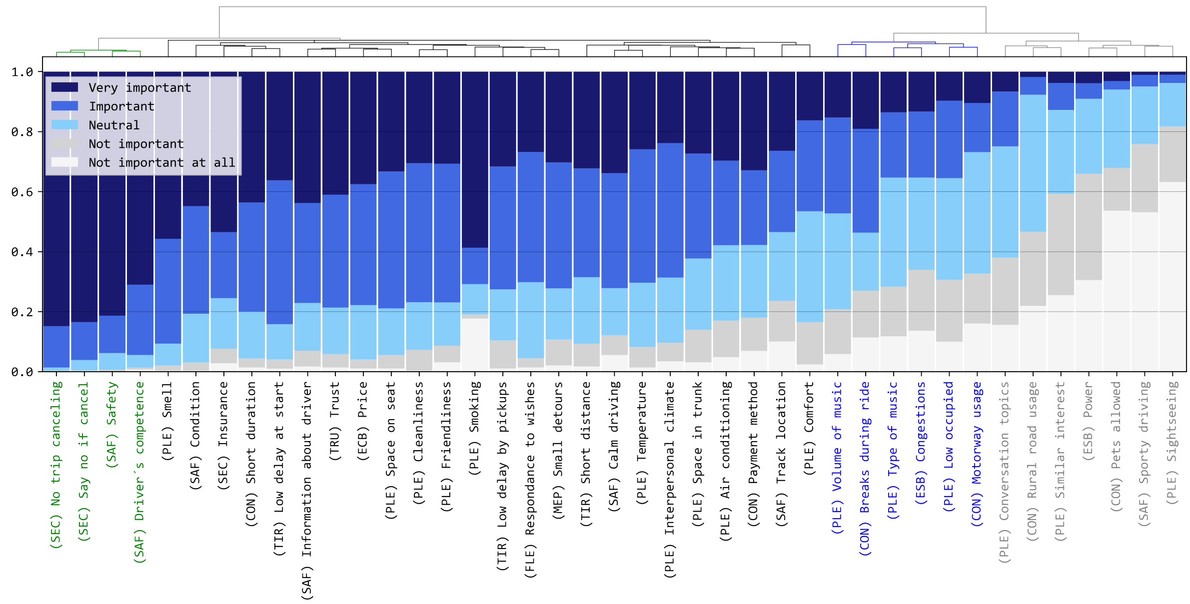

Figure 2: Showing the proportion of answers for the preferences. The preferences are marked with the factors described in Section 4. The order is based on the simple approach.

6 DISCUSSION AND SUMMARY OF FINDINGS

Overall Importances. We have five most important preferences, that with safety, habits concerning cancelling of rides, and smell seem to represent the essentials for participation in ridesharing. Behind that, it is complicated to make a boundary for other preferences, because their importance decreases approximately linear. Nevertheless, looking from the insignificant side, the last seven can be neglected in an assignment process. Interestingly, among these are *power* and *sporty driving*. Comparing the observed ranks with the attention a judgemental factors gets in the literature shows interesting differences. For instance, the economic benefit *price* occurs most often in the literature, but is not in the group or cluster of most important preferences. Environmental and social benefits (*congestion* and *power*), that show up secondly in the literature, end up in the third and fourth most important cluster. The convenience factor group appears in all clusters except for the first one, and our results show that *short duration* of the trip is the most important among its preferences. The factor safety with preferences such as *driver's competence* and *condition* of the vehicle appear in the first and second cluster, showing a relatively high observed importance. Same applies for the factor security. The factor pleasure occurs mostly in the third and fourth cluster, which is similar to its received attention in the literature. However, our survey shows that *space on seat*, *cleanliness*, and especially *smell* are far more important than their occurrence in research. Considering situational factors: The time related factor with preferences such as *low delay at start* are with 61.9 percent relatively important in the literature and accordingly occur in our second most important cluster. The same goes for the factors flexibility and meeting point.

Besides simple being underrepresented in the literature compared to our survey results, we believe that these differences are based on two reasons: Firstly, some preferences like the *price* of a ride are easier to adjust in reality than preferences like *smell* in the vehicle. Secondly, people might care about the *safety* of a vehicle, but in reality you can assume that all vehicles are safe to a certain degree. Nevertheless, our results indicate that the preferences *safety* of a vehicle, *driver's competence*, and *smell* are highly underrepresented in the current research. On the other hand, the preferences *price*, *power*, and *congestion* are overrepresented. Based on our findings we therefore recommend to shift the focus for assignment processes in ridesharing towards the underrepresented preferences.

Importances in Demographic Groups. Regarding age we can contribute the following: Interestingly, besides younger people also those over the age of 34 care most about *congestions*. For younger people safety and security related factors are more important. Regarding gender: For women in general

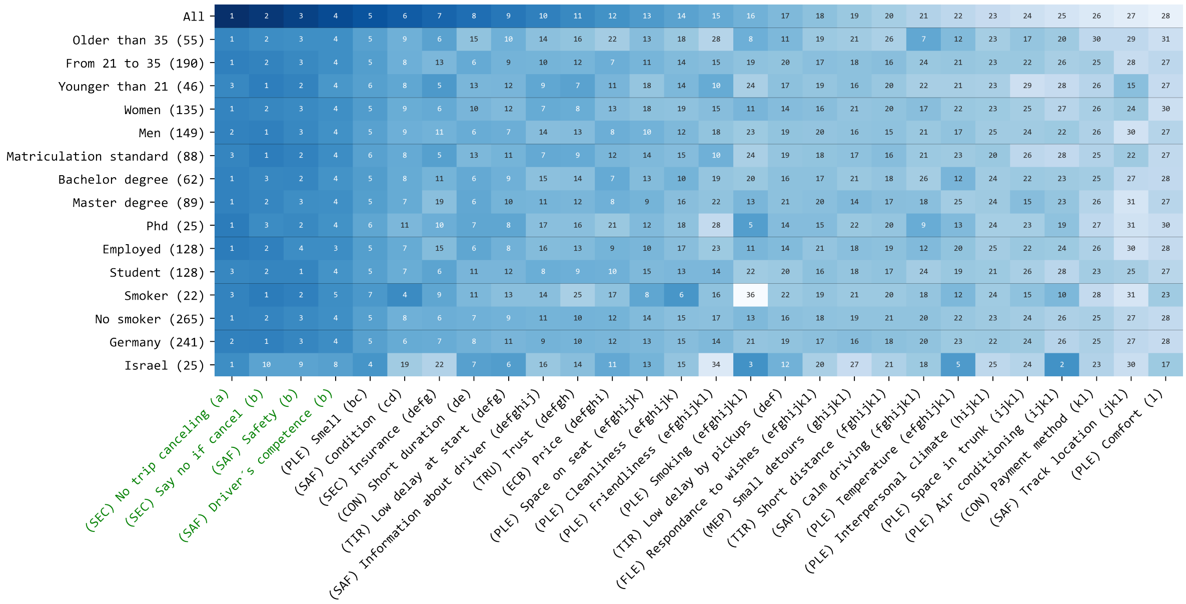

Figure 3: One row shows the observed order of preferences for a demographic subset based on the simple ordering approach.

security factors such as *information about driver* and environmental aspects are more important for women.

Regarding education level: People holding a matriculation standard or a master degree care more about friendliness. However, for people with a matriculation standard safety related preferences are more important, whereas for master degree holders time and pleasure related preferences are more important. Regarding country of residence: We believe, that the temperature in a car and its ability to regulate such are more important for Israelis due to higher temperatures in Israel. Moreover, we believe that smoking is most important for Israeli residents due to religious reasons. However, this cannot be proven, because we did not collect corresponding demographic data. Our results indicate, that the preferences of people highly depend on their cultural background. Nevertheless, because the number of Israeli residents is relatively small, almost all of our results are limited to German residents. Regarding smoking: we observe a high difference concerning the rank of smoking between smokers and non-smokers. This indicates the importance of smoking for non-smokers because want to avoid it. Besides, the proportions in Figure 2 show an irregularity at *smoking*. We believe this is caused by two things: The answers are bipolar distributed and the question is partly misunderstood.

Limitations. In the questionnaire we asked the participants to list preferences not considered. Three people mentioned services like free internet connection, snack food, and providing electricity to passengers, which could be considered in the future for ridesharing in general and for assigning. The same applies to rules regarding food during a ride, which was also mentioned three times. Besides not including these additional preferences, it has to be noted that this paper only considered preferences of passengers and excludes the ones of drivers. This could be investigated in the future. The results from the questionnaire might be wrong for some preferences, because a mismatch between observed (implicit) and self-reported (explicit) importance of certain, similar to trust (Papenmeier et al., 2019), can appear. Moreover, our results indicate, that the conclusions drawn in this section are limited to German people.

Future Research. To foster human-centric ridesharing, we propose two directions for future research:

- First, user preferences shall be simulated based on the gathered data. Taxi trip data like New York City taxi (see (Donovan and Work, 2016)) data are already publicly available, but these do not include preference characteristics of users. We want to apply generative models, that are able to generate synthetic results based on provided training data, to add user preferences to existing datasets.

- Second, these preference characteristics shall be considered to enable more human-centric ridesharing. To do so on a larger scale, we assume that AI algorithms will be necessary.

7 CONCLUSION

After analyzing factors and preferences that influence ridesharing based on the literature, we conducted a survey to identify the preferences important for users to be satisfied within an ridesharing assignment process. Based on these two, we were able to provide a comprehensive list of preferences relevant for ridesharing and we contribute an order of such based on relative importance. In addition to that, we also compared the importance in demographic subgroups and collected significant differences among them.

Summarizing, comparing the observed importance and the preferences occurrence in the literature, we could not identify differences in situational factors. Nevertheless, we observed high differences in judgemental factors, that should be considered in future research and applications. Based on our findings regarding the assignment process in ridesharing, we recommend to focus on underrepresented preferences such as *safety* of a vehicle, *driver's competence*, and *smell* and to not focus on the overrepresented preferences *price*, *power*, and *congestion* too much. Comparing different demographic subgroups, we showed some additional findings, but overall and similar to previous work the differences are relatively small. However, our results indicate a high influence of the country of residence to the relative importance of preferences.

ACKNOWLEDGEMENTS

The VolkswagenStiftung partly supported this work.

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