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Increase Occupancy Rate in Passenger Cars – Potentials of Awareness Raising for Carpooling

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1 ABSTRACT

Transport is responsible for 30% of Austria's CO_2 emissions. Of these, 17.13% are caused by passenger cars. Car traffic (kilometres driven) has increased significantly in recent years, while at the same time, the occupancy rate is continuously decreasing and is currently only 1.15 persons per car in Austria. Due to the traffic load and the associated negative environmental impacts, there is a great need to increase the occupancy rate in passenger cars. The shared mobility concept of carpooling offers starting points to counteract this trend. In this context, carpooling in particular shows great potential for reducing the volume of traffic. Carpooling reduces emissions and lowers the risk of accidents, and an improvement of occupancy rate of cars can reduce traffic by up to 10%. However, the "critical mass" of carpooling platforms is often not reached and there is a lack of adequate advertising and communication measures. Traditional advertising channels such as print rarely reach the entire target group in the shared mobility sector and digital advertising channels miss internet-averse target groups who hardly use social media.

This article is therefore dedicated to the evaluation of an advertising campaign that aims to increase awareness and acceptance of the accelerated use and market penetration of carpooling offers. By means of a digital display placed at the side of the road, attention was drawn to the degree of occupancy by means of various statements - with the aim of triggering a rethink in the direction of carpooling. Based on a preliminary survey, the perception and acceptance were surveyed using feedback from passers-by and app users. The main finding is that many car drivers noticed the display and rated it as positive. Ultimately, however, only a small number of people could be motivated to use carpooling or to give other people a ride. The main barriers to use carpooling are the lack of schedule flexibility, reliability of passengers and loss of time.

Keywords: signage, ridesharing, carpooling, awareness, Occupancy rate

2 BACKGROUND AND STATE-OF-THE-ART

The occupancy rate in Austrian vehicles is 1.15% (VCÖ 2017). In other words, most people drive predominantly alone, leading to resource consumption, increased traffic, environmental pollution, and an inefficient use of transport systems. At the same time, this low utilization represents a great potential (Mühlethaler et al 2011). Ridesharing and carpooling, as part of shared mobility, are promising concepts that can counteract the low utilization of passenger cars and the associated consequences. Both terms are often used synonymously, but important distinctions exist (see 2.1.). What they have in common is that by pooling routes, several people can share one vehicle. This is often based on mobile solutions that facilitate booking and payment for the drivers. Both concepts still have an awareness and image problem, for which there are various approaches to raising awareness.

2.1 Carpooling and ridesharing as sustainable transport modes

Carpooling and ridesharing are promising tools when it comes to sustainable mobility. Carpooling involves a group of individuals sharing a single vehicle to travel together, usually for a regular commute or a specific trip. Typically, the passengers and the driver know each other, are part of the same organization or community, or are matched through a digital platform (Shaheen 2018). Ridesharing involves connecting individuals seeking transportation with drivers through a digital platform or mobile application. The drivers provide transportation services in their own vehicles for a fee, and passengers are typically strangers to the driver. Uber is often mentioned as a Ridesharing service from the American perspective (Wallsten 2018). This primarily serves as an on-demand transportation service, allowing individuals to request rides as needed. In this article, ridesharing is referred to as a shared trip transportation option rather than an on-demand transportation service. In contrast to carpooling, ridesharing represents a transportation option for

spontaneous trips (Furuhata et. al. 2013). Especially in rural communities, carpooling and ridesharing offer great potentials and until now, it has been considered as a supplement to public transport, which is still insufficiently established. However, there are “many influencing factors to consider - local and temporal distributions of demand, specific trip requirements, and attitudes of potential participants toward car pooling” (Mühlethaler et al 2011).

2.2 Mobile Solutions

Ridesharing and carpooling depend predominantly on mobile solutions which organize the communication and connection between the users (someone offering a ride and someone requesting a ride). Today, numerous online platforms exist in Austria for the organized networking of unknown persons (e.g. BlaBlaCar, Mitfahrgelegenheit.at, mitfahrzentrale.at). It is striking that the ride offers on these intermediary platforms are primarily limited to longer distances (usually several hundred kilometres). Pave Commute for example, offers a white-label solution for employers to connect employees, using commuting time wisely and reducing CO_2 emissions. Pave Commute focuses on B2B use and is mainly used by employees of medium-sized and large companies (Pave Commute 2023).

2.3 Signage as a nudging mechanism?

There are different possible ways to motivate commuters toward a more sustainable behaviour. “Nudging" is one way to change behaviour and refers to influencing the behaviour of an individual without monetary incentives (Thaler & Sunstein 2008). In road traffic for example, nudging is well known in the form of visual speed feedback. A study showed that displays that communicated verbal feedback such as "thank you" or "slow down" were more effective than those with a pure speed display (Schulze & Gehlert 2010). In terms of occupancy levels, there are defined carpooling lanes in the US, which are reserved for the exclusive use of vehicles with a driver with one or more passengers (Javid at al 2018). In the field of mobility sharing, there are only very few empirical studies in the context of nudging and these tend to be applied in the "offline" world (Dörrzapf at al. 2019, Namazu et al., 2018).

In this project, nudging is thus understood as "soft" measures that influence people in their decision-making and behaviour, whereby it is crucial that freedom of choice is always enabled. Nudging in this case is linked with digital signage and positive reinforcement. This project is the first to apply this principle to the occupancy rate of cars. The combination of individual feedback from the roadside in combination with the promotion of alternative mobility solutions has not yet been scientifically evaluated in such a form. If it is effective enough, it can create a completely new communication channel for environmentally friendly mobility, which will bring new momentum to the transport transition.

3 METHODOLOGY

3.1 Goals and settings

The project aimed to foster ridesharing and carpooling through the app Pave Commute as an innovative, user-friendly solution. Furthermore, the awareness and acceptance of commuters for ridesharing and carpooling should be increased in the test area by implementing an “awareness campaign”. The other component is the hardware: a digital display, which provides feedback on the occupancy rate of a passing car to the commuter themself.

3.1.1 Software

As part of this project, the app was opened up and made available to all citizens of Amstetten for free use. In the course of the technical onboarding the Amstetten ride-sharing platform was created in the app, which was accessible in just a few steps and gave app users the certainty that local carpools with people from the region were in the foreground. Data collection and processing of user requests during the awareness campaign were also prepared.

3.1.2 Hardware

In this research project, the prototype of an innovative street installation was used to carry out the awareness campaign. The survey of the respective occupancy rate of passing cars was carried out on site by a team using a manually operated input device (Windows tablet with specially programmed interface), as is still

used in many places for occupancy rate surveys. This input device in combination with two specially assembled feedback displays resulted in the prototype of Carpacity. With the help of a streetscape installation, "praise" and "thanks" were presented to the drivers. However, gentle feedback should also encourage solo commuters to reconsider other means of transport (see Figure 1).

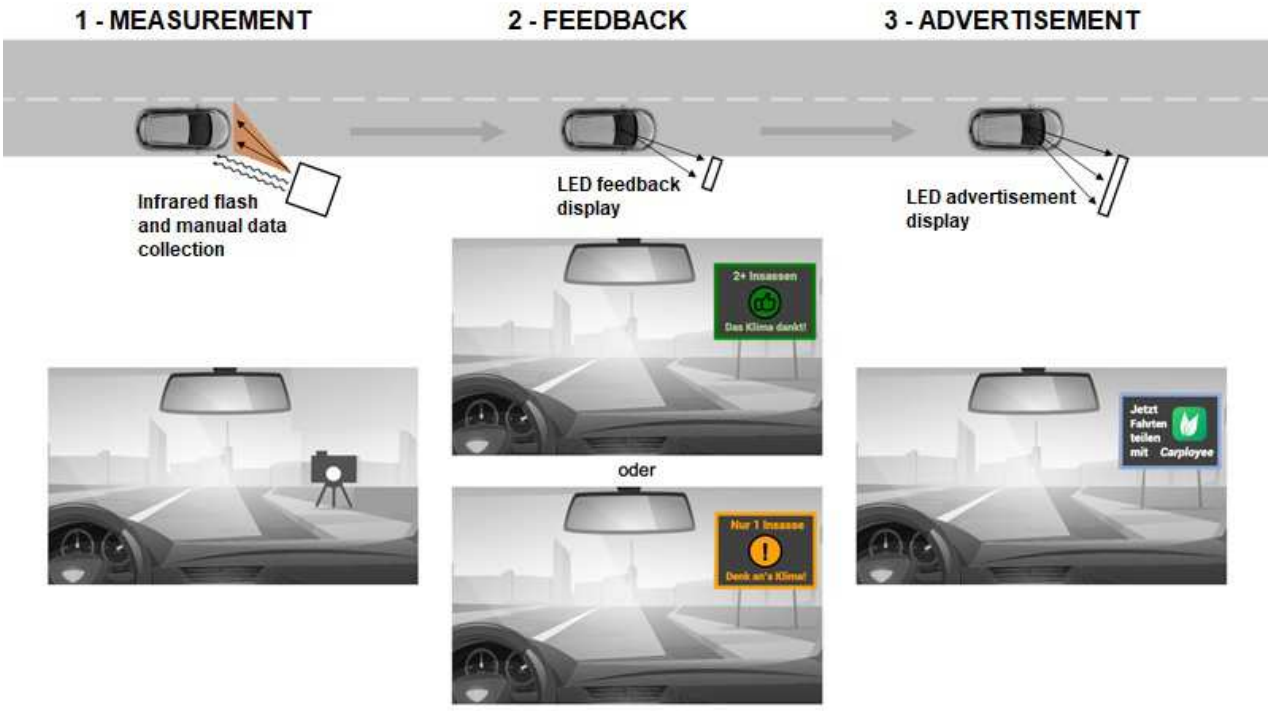

Fig. 1: Streetscape installation as digital signage (source project "Happy smileys for full cars")

3.2 Methods

3.2.1 Preliminary Questionnaire

	Group 1	Group 2	German average
Age			
0-20	2,4%	4%	18,8%
21-40	56%	55,9%	24,5%
41-60	35,2%	32,7%	27,3%
61-80	6,4%	7,1%	22,2%
81+	0%	0,3%	7,2%
Gender			
Male	60,8%	67,2%	49,3
Female	38,9%	32,8%	50,7
Other	0,3%	0%	n/a
Highest level of education			
Apprenticeship	14,9%	14%	46,6%
Middle school	8,8%	14,4%	23,5%
Matriculation/Secondary education	27,4%	26,8%	33,5%
Higher education	**46,9%**	**42,1%**	18,5%

Table 1: Comparison of the two sample groups to the German average. Source: Statistisches Bundesamt, 2019; 2022

Data collection throughout the project took place through four main channels. During the project, a preliminary online survey to generally assess perceptions and attitudes of individual occupancy level feedback LED displays were incorporated into the design of the experiment. The questionnaire collected socio-demographic characteristics, patterns of mobility behaviour, but most importantly participants were asked to imagine themselves experiencing the awareness campaign. This was "simulated" by a picture story. In the simulation, group one (N=296) was driving by a feedback display that slightly criticised their low rate of car occupancy before passing by the PAVE Commute ridesharing advertisement. Group two (N=299) did not pass by a feedback display at all before passing the advertisement. Subsequently, participants were asked

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about their perception of the campaign, their attitudes towards carpooling in general and their openness to using the PAVE app.

A total of 595 Participants were recruited using the Clickworker platform. As 91,7% of the respondents currently reside in Germany, participant representativeness will be compared to the German average. Despite slight differences in middle school respondents, a certain degree of comparability is achieved between the two groups (see Table 1). Compared to the German average, the sample significantly overrepresents younger and highly educated men. The findings therefore represent a specific sub-group and cannot be generalised to the broader German population.

3.2.2 Awareness campaign

The main experiment revolved around the 6-week awareness campaign consisting of a station where oncoming traffic was manually analysed with regards to the rate of occupancy by trained staff, during peak hours in the morning (primarily from 6:00 to 9:00) and the afternoon (primarily from 14:30 to 17:00). All entries were made using a tablet, which stored the data in real time and forwarded it to the feedback displays 30 meters further down the street, thereby allowing for personalised feedback to be created.

Two LED displays were installed 150 meters apart on the busy B1 street entering Amstetten from the east (see Figure 2). The first display either provided positive feedback to vehicles occupied by two or more people or nudged vehicles with only one passenger with slightly negative feedback. All passing vehicles would see an advertisement for PAVE Commute, an app to organise carpooling and ridesharing on the second display.

Fig. 2: Location of the pilot project on the B1-Reichstraße at the eastern entrance of Amstetten and view of the green strip where the feedback displays would later be implemented (source project “Happy smileys for full cars”)

The exact slogans of the feedback and advertising displays as well as other measures to further carpooling practices were discussed at a workshop and information event with local stakeholders. It was decided that displays with a local reference, for example “Amstetten says thank you” and emphasis on the cost-saving potential of carpooling were preferred.

Fig. 3: Two positive feedback signs, two negative feedback signs and two advertisements used during the awareness campaign (source project “Happy smileys for full cars”)

Parallel to the implementation of the pilot project, an online survey recording the perception and impact of the installation was conducted with participants in Amstetten. A total of 77 responses were collected, 26 of which had passed the installation. Participants were recruited by means of social media, billboards, e-mails and personal contact. Due to the relatively small sample size, the main focus of the questionnaire lies in its

qualitative elements, where participants were able to write detailed accounts of their experience and perception regarding the installation.

3.2.3 Traffic counts

As part of the awareness campaign, the vehicles that passed the displays were also counted and classified by means of a visual inspection of the trained staff. This was done using a simplified classification tool allowing categorisation into the following: buses, larger and smaller trucks, vans, cars, cars with trailers, motorcycles, bicycles and non-classified vehicles. Likewise, the rate of occupancy for each vehicle was recorded. Each data entry also included a timestamp with the day of the week, date and time when the entry was made.

3.2.4 Smartphone app user data

Being able to utilise the project partner's data from the PAVE Commute app, further analysis could be conducted on the user-data in Amstetten. Most importantly, this included data such as the number of app downloads in the region, the number of completed onboardings, new carpooling groups created, tracked commutes. Utilising user data was a key parameter allowing to evaluate the success of the awareness campaign.

3.3 Data Analysis

A mixed-method approach was employed throughout the data analysis process. Statistical analysis of the two groups was used to analyse and compare findings in the preliminary questionnaire. Likewise, with the data regarding the number of vehicles, vehicle classification, rate of occupancy. The written replies within the awareness campaign survey highlighting participants' perception and impact of the feedback displays were assessed using qualitative content analysis.

To illustrate the potential for work-related carpooling beyond the app, 35 home and workplace locations collected in the awareness campaign questionnaire were utilised using georeferencing to create a network analysis of potential commuting routes in Amstetten. The commuting routes reflect the fastest connection between home and workplace and may therefore not reflect actual routes.

4 FINDINGS

4.1 The role of individual feedback displays in shaping car-occupancy levels

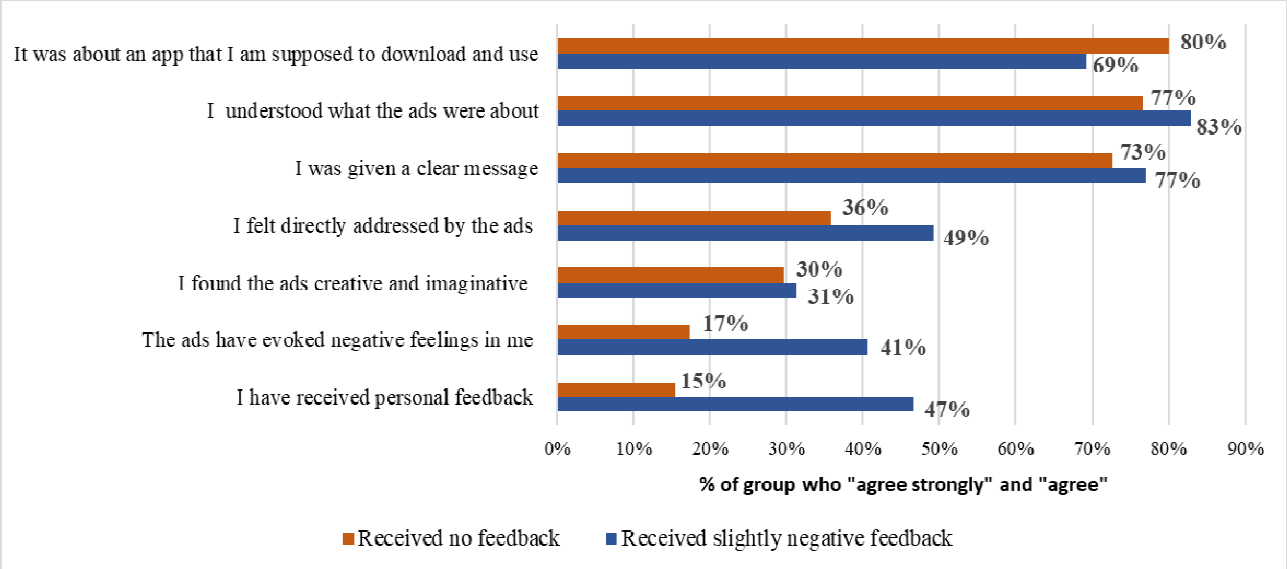

Fig. 4: Experience of simulated feedback and advertisement displays (N=595)

As part of the preliminary questionnaire, 595 participants from outside of Amstetten underwent an image guided simulation of passing the LED feedback displays. Group 1 (N=296) received slightly negative feedback before passing the advertisement whilst group 2 (N=299) did not receive any feedback at all before passing the advertisement. Comparing different perceptions of the simulated experience (see Figure 4), both groups emphasised that they had understood the feedback and advertisement displays and characterised them

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as providing a clear message about downloading and using a carpooling app. Many more participants who received feedback felt addressed more directly (49%) than those who just saw the advert (36%) and felt more personally addressed. At the same time, those who received slightly negative feedback were more often experiencing negative feelings (41%) compared to those who did not (17%). It can therefore be said that feedback displays provide an opportunity to directly and personally address drivers whilst also carrying the risk of evoking negative emotions.

In addition, the survey aims to illuminate the potential of the simulated nudging experience on attitudes of carpooling and openness to utilise the advertised smartphone application. Regarding attitudes of carpooling (see Figure 5), participants who have received slightly negative feedback within their simulation showed more negative attitudes towards carpooling. Accordingly, whilst they were equally open to riding in other people's cars, they were less open to taking other people with them (20%) compared to those who have not received feedback (25%). Likewise, those who did not receive feedback agreed more strongly on the importance of not driving by themselves for environmental reasons (85%) than those who received slightly negative feedback (72%).

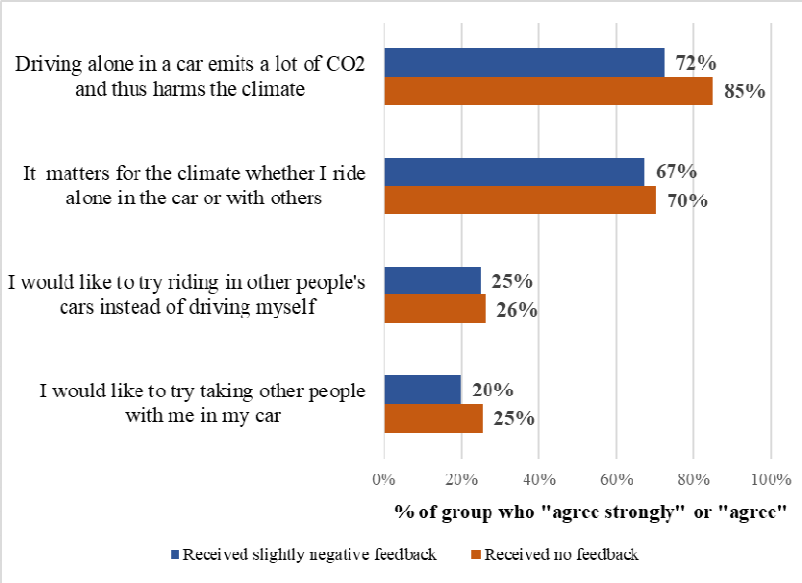

Fig. 5: Attitudes towards carpooling (N=595)

Similarly, with the openness to using the carpooling app, participants who have received slightly negative feedback in the simulation were generally less open to use the PAVE Commute app to organise carpooling both as a driver (see Figure 6) and as a passenger. Accordingly, only 19% of participants who had received feedback could imagine themselves commuting with the PAVE app several times a day, daily or several times a week as a driver compared to 27% of those who had not received feedback.

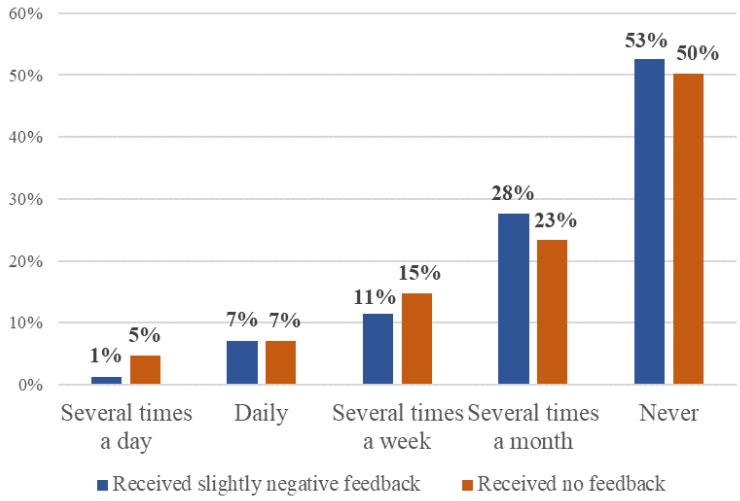

Fig. 6: Openness to using the PAVE Commute app to share car trips as a driver (N=595)

Likewise, only 20% of participants who had received feedback could imagine using the PAVE app to commute as a passenger several times a day, daily or several times a week compared to 24% of those who did not receive any feedback. Generally, willingness to commute as a passenger was higher than to be a driver. Whereas an average of 48,5% across both groups were open to driving others, an average of 52% could imagine themselves as carpooling passengers. This echoes data from the US, where the rate of people who wanted to be a passenger was generally higher, primarily for people who did not own a car themselves (Park et al., 2018). This pattern continues when it comes to expressed motivations of testing the carpooling app. Overall, only 18% of participants who had received feedback on their car occupancy expressed feeling strongly motivated or motivated compared to 29% of those who had not seen feedback.

4.2 Factors shaping vehicle occupancy rates in Amstetten

Throughout the process of the awareness campaign, the number and type of passing vehicle and the number of occupants within the vehicle were counted by trained personnel. The timeframe of data collection included workdays (Mondays to Fridays) from the 4.10.2022 to the 20.10.2022. In general, findings from the project indicate an average annual daily rate of traffic of 15.000 vehicles. This contrasts with earlier automated counts on Amstetten's B1 in 2019, which have arrived at an annual average daily rate of 13.000 vehicles (NOE, 2020). As emphasised in Figure 7, traffic peaks of up to 850 vehicles per hour occurred between 6:40 and 7:00 am. Isolated peaks may be explained in reference to shift changes in the surrounding industrial area

Throughout the recorded timeframe, the vast majority of recorded trips were made with cars occupied by only one occupant. Other modes of transportation such as bicycles, buses or motorcycles play a negligible role in the traffic volume. Considering the split of vehicle types recorded throughout the experimentation phase, cars made up 84% of the traffic. Amongst the cars recorded, 77,5% were occupied by a single person. Likewise, amongst the local participants from Amstetten who participated in the main questionnaire (N=77), 93,5% reported work as their primary reason to commute. This and the large share of single-occupancy rides reflects the continuing potential for carpooling as a means to reduce individual transport, especially for work trips.

Whereas car trips with only one occupant were especially dominant throughout the morning hours, a clear increase in the number of car trips with two or more occupants can be observed in the afternoon, when cars were occupied by an average of 1,3 to 1,35 people. Especially in light of the high volume of morning traffic, car occupancy rates in these hours remained between 1,15 and 1,2 individuals per vehicle. Findings from Amstetten are thereby generally slightly below the Austrian average of 1,3 for all trips and especially for the rate of 1,7 for recreational traffic (Österreich Unterwegs, 2013/14).

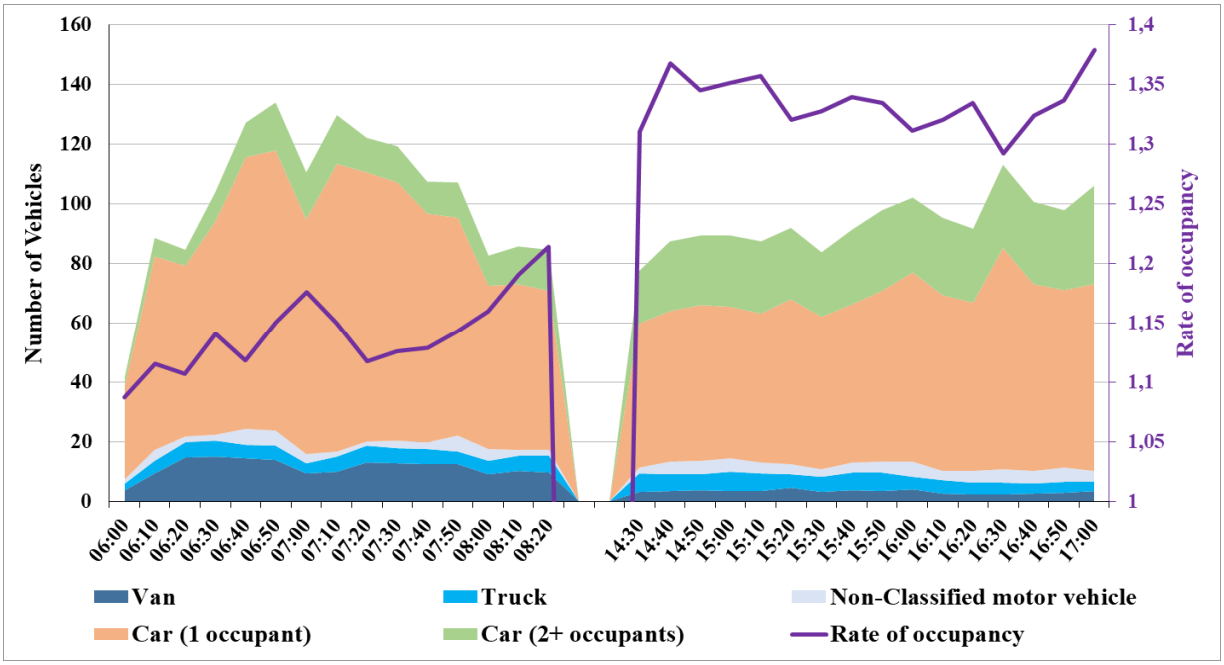

Fig. 7: Average daily rate of traffic as per type of vehicle and rate of occupancy 4.10.2022 - 20.10.2022

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The highest traffic flow of 120 cars per 10 minutes between 6:40 and 7:30 only shows a rate of occupancy of 1,1 to 1,17 people per car. This could be explained by the high volume of single-person workplace traffic in the morning in contrast to more recreational traffic in the late afternoon and evening. To illuminate other factors shaping the rate of occupancy, weekdays have been considered. In this context, the rate of occupancy has been examined during traffic peak hours. Only minor variations in vehicle occupancy from 1,12 on Tuesdays to 1,15 on Mondays can be observed at the first peak of the day from 07:00 to 08:00 in the morning. In contrast, occupancy rates during the second peak from 15:00 to 16:00 remain at stable levels between 1,32 and 1,34 from Monday to Thursday but rise significantly to 1,39 on Friday afternoons, thereby echoing existing findings highlighting the correlation between occupancy rates and recreational traffic on weekends (Rapp et al. 2001).

4.3 The impact and perception of Amstetten's nudging awareness campaign

Amongst the survey respondents in and near Amstetten (N=77), a general inquiry of carpooling perceptions has been conducted. Accordingly, most respondents had a positive (18,2%) or rather positive (26%) rather than negative (7,8%) or rather negative (16,9%) perception of carpooling. The largest group, however, has expressed neutral views (31,2%) towards carpooling. Elaborating on their response through an open question, participants have especially highlighted the financial and ecological benefits of carpooling. On the other hand, lack of flexibility, dependency on others as well as discomfort of travelling with strangers were amongst the key disadvantages that have been named. Potential drivers have highlighted the barrier of being responsible for their passengers. Potential passengers on the other hand occasionally referred to the lack of knowledge of the driver's driving style as a negative factor. Some participants have thus referred to carpooling as "saving money, stress free" but also negatively in terms of the "lack of punctuality of passengers" or "feeling not comfortable carpooling with strangers". Whereas the findings further illustrate the potential of carpooling as a means of contributing to more sustainable patterns of mobility, there is an ongoing need for social or technological innovation to overcome some of its inherent limitations.

Building on the rather positive perception of carpooling, the experiment has explored the potential of LED displays to improve car occupancy levels by nudging single occupant cars with slightly negative feedback whilst providing positive feedback to cars occupied by two or more people coupled with creating awareness for a carpooling app. Quantitative analysis of responses to the nudging signs is limited in terms of the low number of participants who have filled in the main survey and also passed the signs (N=26). Of those who have passed and read the nudging display, open text replies in the questionnaire have provided mixed feedback. Overall, 48% of the qualitative responses were positive, 26% negative and 26% neutral. This was partly based on the display being perceived as unnecessary and overly intrusive. Accordingly, participants emphasised how they "had a guilty conscience because I was driving alone, but at the same time were a bit annoyed, because I can't take anyone with me". Others have highlighted, that the displays were "prompting but not encroaching" has provided a thought-provoking impulse, since they "always go to work alone".

Feedback towards the advertisement display were much more negatively amongst the participants in Amstetten who had passed it (N=26). In total, 63% of the qualitative responses were negative, 31% positive and 6% neutral. Consequently, whilst some referred to the advertisement as evoking positive connotations of "carpooling is good", the majority experienced it as "one of many useless distractions on the road" or another advertisement for "just one more app on the phone".

Following the instalment of the field experiment in Amstetten, the app activity in the region was closely monitored. During the time of the experiment, a total of 66 new users have downloaded the app and registered for the Amstetten commuting platform. Of those, 48 have completed the onboarding process of getting familiarised with how PAVE functions leading to a total of 9 new commuting groups being established. Despite registration numbers in Amstetten growing much more significantly during the experiment in comparison to the time after the experiment, the goal of 250 downloads had not been reached. A total of 29 carpooling rides have been registered during the experimentation phase, connecting individuals with similar times and routes of travel.

Illustrating local potential of work-related carpooling in Amstetten, 35 home and workplace locations were utilised using georeferencing. Maps were created reflecting potential commuting routes in Amstetten (see Figure 8). As the routes reflect the fastest connection and route choice is generally subject to various factors

such as personal habits or potential stops along the way, it is important to highlight that actual routes may differ.

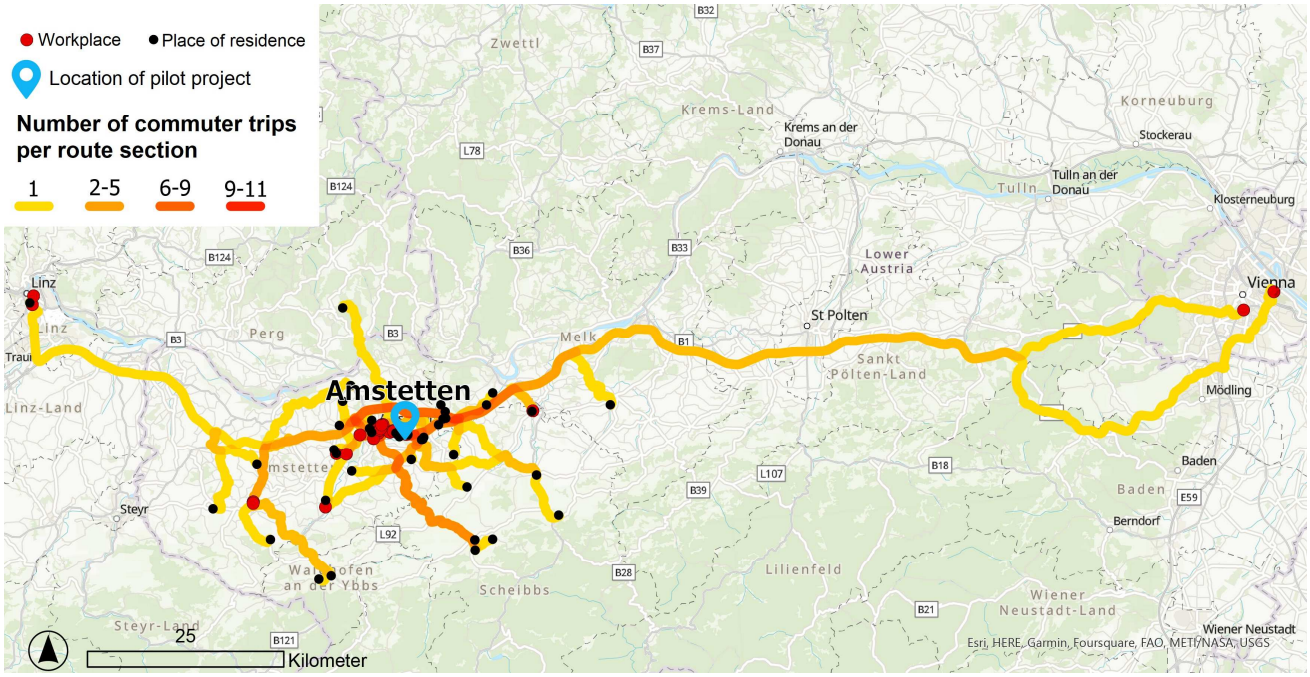

Fig. 8: Network analysis of potential commuting trips in Amstetten from 4:00 – 9:00 o'clock

As can be seen in the figure, there is a limited accumulation of commuting routes and thus a lower potential for shared car trips. Whereas workplaces are strongly concentrated in the city of Amstetten, the places of residence are dispersed across the region. This may be due to the low levels of elevation in the region, resulting in few clusters of roads. Carpooling may therefore hold more potential in mountainous areas where traffic is limited to fewer and more concentrated roads.

In addition to the spatial dimension of potential routes, the time of departure and arrival also plays a critical role. Potential routes were analysed in 60-minute increments. Whilst the highest potential for carpooling was identified between 5:00 and 7:00 in the morning, the differing temporal needs of commuters generally further limits the chances for carpooling.

5 CRITICAL REFLECTION

The following section involves the critical reflection of the methodology and other implications of the study like the challenge of the critical mass.

5.1 Methodological limitations in the preliminary questionnaire

Whereas it seems that the feedback displays might have negatively impacted the participants' perceptions and attitudes of carpooling and their openness to utilise carpooling apps, the differences between the two groups is not significant. It therefore remains questionable whether these differences result from the simulation or if they just reflect differences amongst the two sample groups. Other statistical methods like t-test or ANOVA could be considered. The findings do, however, highlight low levels of awareness and sense of relevance of increasing car occupancy levels as an important sustainability measure. Additionally, it has to be considered that the simulation on a display does not reflect real world conditions and social desirability might have played a role in the preliminary questionnaire.

5.2 The critical mass problem

The network analysis of potential carpooling illustrates the need for platforms to navigate both spatial and temporal differences in their matchmaking. This reflects the fundamental dependence of app providers on high numbers of users as a prerequisite for offering carpooling options. Especially in rural and less dense areas this aspect becomes even more of a challenge. Whereas the use of awareness campaigns using feedback displays and nudging can certainly contribute to establish this critical mass of users on carpooling

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platforms, other measures such as the integration of multiple communication channels on different types of media or the inclusion of carpooling options in existing MaaS apps (Wright at al. 2020).

In addition, it can be assumed that longer detours and longer travel times tend to lead to a higher rejection rate. Which factors influence this refusal requires further research (König & Grippenkoven 2020).

6 CONCLUSION AND OUTLOOK

In the project a striking campaign was used to raise awareness for sustainable mobility in road traffic. It can be summarized that participants who received slightly negative feedback felt more directly addressed and experienced more negative feelings compared to those who did not receive feedback. Additionally, participants who received feedback showed more negative attitudes towards carpooling and were less open to utilizing carpooling apps compared to those who did not receive feedback. The majority of recorded trips in Amstetten were made with cars occupied by only one person, indicating the potential for carpooling to reduce individual transport. Car occupancy rates in Amstetten were generally below the Austrian average, with an increase in the number of car trips with two or more occupants observed in the afternoon. Participants in and near Amstetten had mixed perceptions of carpooling, with positive views emphasizing the financial and ecological benefits, and negative views highlighting the lack of flexibility and discomfort of traveling with strangers. The experiment with LED displays for nudging car occupancy levels received mixed feedback, with some participants perceiving it as unnecessary and intrusive, while others found it thought-provoking. Overall, the findings suggest that feedback displays and nudging interventions have the potential to shape car-occupancy levels and attitudes towards carpooling, but their effectiveness and acceptability can vary among individuals.

The findings from the research project can be used to increase awareness and acceptance of shared mobility services such as carpooling and ridesharing, and thus reduce the number of private cars on public roads. In addition to the promotion of carpooling, as was done in this project, a number of other mobility offers and modes such as on-demand transport (call buses, shared taxis, on-demand mobility, etc.) could be the focus of a further awareness campaign in road transport. In the course of follow-up projects, omni-channel communication campaigns should be taken as a basis to further increase the effectiveness of awareness campaign. All available channels can be used (posters, flyers, social media, etc.) to achieve a strong and repeated involvement of all stakeholders.

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