Information on Capacity Utilization for Public Transportation: Useful for Passengers?

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ABSTRACT

Crowding in public transportation (PT) is a major challenge that has negative economic consequences for providers and negative psychological consequences for passengers. With more and more people using journey planner apps and the increasing availability of precise information on capacity utilization (CU) of PT, providing information on alternative, less crowded route options to passengers, is possible. In order to determine when, how and where the information on CU needs to be displayed and for whom it is especially useful for planning a trip, an online study was administered. An objective of the study was to investigate the use of journey planner apps among public transport users in more detail. In particular, the frequency and timing of app use for different trip purposes were investigated. Another goal was to identify under what circumstances public transport users perceive information on CU as useful. Results ($N = 204$) show that the frequency and timing of the use of journey planner apps differs depending on the trip purpose. People from metropolitan areas use journey planner apps less often than people from smaller cities. Trip purpose, duration of the trip, and service frequency have an influence on the perceived usefulness of information on CU. Important insights on the use of journey planner apps and the optimal conditions for the target group specific provision of information on CU could be gained with this study. The results can be used to derive strategies and recommendations for PT service providers.

Keywords: public transportation, passenger information, capacity utilization, usefulness.

1. INTRODUCTION

Overcrowded public transport (PT) is especially at peak times a widespread challenge in large cities. It is associated with several negative consequences for passengers and for transport companies. Frequent trips in overcrowded public transport lead to higher stress levels (Legrain et al., 2015), a lower safety and security perception (Cox et al., 2006), and overall diminished performance abilities (Evans & Wener, 2007). Transport companies experience economic detriments due to longer dwell times in stations and in consequence delays in the entire PT system (Yuan & Hansen, 2007). At the same time, in order to achieve the goal of a sustainable transport system, even more people need to switch from individual motorized transport to public transportation. Recently introduced measures, such as the 49-euro ticket in Germany, are expected to drive this trend. However, due to cost- and time-intensive implementation, the increasing demand for public transportation cannot be met with capacity extension alone, but must be predominantly carried out within the existing system. An approach to accomplish this is to provide passengers with accurate and reliable information on capacity utilization (CU) in advance of their trip directing them to lower-demand connections. Previous study results show that, in

general, passengers are willing to adapt their PT usage behavior to current information about the trip (Drabicki et al., 2017; Kattan & Bai, 2018). However, no results about the user requirements of this kind of information are known to the authors.

A basic prerequisite for the desired change in PT usage behavior is that passengers perceive information on CU as useful. The various conditions under which PT journeys are made must be considered. Thus, the purpose of the trip, the length of the trip, and the service frequency of the mean of transportation are expected to influence the perceived usefulness of information on CU. The way this information is optimally provided is also relevant. Journey planner apps for PT are a widely used medium for providing passenger information and are used by most passengers (Islam et al., 2017). So, the usage behavior of these apps is of high interest. General frequency and timing of the use of journey planner apps for different trip purposes are relevant. Regarding the questions about the perceived usefulness of information on CU as well as the use of journey planner apps, it is expected that the local PT infrastructure also plays an important role. Metropoles - such as Berlin - are characterized by a variety of different modes of public transportation resulting in several route options for a specific journey. In contrast, in smaller cities, only one possible route option with much lower service frequencies is more likely. Accordingly, differences in frequency and timing of app use are expected between people from a large city and people from smaller cities.

Several objectives emerge for the present study. In order to investigate the requirements for a target group specific provision of information on CU, the perceived usefulness of these information will be analyzed depending on trip-specific and person-related factors. Questions regarding the use of journey planner apps are intended to provide insights into the optimal provision of the information. Furthermore, the general public transport usage behavior will be surveyed as an influencing factor. The results of people from Berlin will be compared with the results of people living in smaller cities.

2. Method

To answer the research questions, an online study via SoSci-Survey was conducted. The survey period was between November 2022 and January 2023. The questionnaire started with questions about the demographic characteristics of the participants such as gender, age, and the number of inhabitants of the place of residence. Furthermore, it was asked whether the persons came from the federal state of Berlin or Brandenburg. Based on this information, persons living in Berlin could be identified and thus the groups could be formed. This was followed by questions on PT usage behavior, the use of journey planner apps and the perceived usefulness of information on CU for different trip-specific factors. Questions regarding the frequency of PT use had to be answered on a 7-point scale from "on a daily basis" to "never". For the frequency of the use of journey planner apps a 7-point Likert scale ranging from "for every trip" to "never" was used. Regarding the perceived usefulness of information on CU, participants rated a statement (e.g. information on CU are useful for me) on a 5-point Likert scale ranging from "I completely disagree" to "I completely agree". Altogether, 204 people participated in the

survey. Table 1 shows the demographic information of the sample split for people living in Berlin (PLB) and people living in smaller cities (PLSC).

Table 1 - Demographic information of the sample

|	PLB	PLSC
N	85	119
Mean age (SD)	33.5 (12.7)	32.9 (13.8)
Gender		
male	58.8%	63.0%
female	35.3%	33.6%
divers	3.5%	1.7%
not specified	2.4%	1.7%

PLB = people living in Berlin, PLSC = people living in smaller cities

3. Results

3.1 Use of journey planner apps

Results show that participants used journey planner apps for most of their trips ($M = 5.85$, $SD = 1.35$). No difference was found between people who used PT once a week or less ($N = 60$) and people who used PT at least 3 times a week ($N = 144$). Comparing the results of PLB ($M = 5.42$, $SD = 1.46$) and PLSC ($M = 6.16$, $SD = 1.16$), PLSC showed a significantly higher usage ($p < .001$, $d = 0.57$).

Figure 1 shows Means and standard errors (*SE*) of the usage of journey planner apps for different trip purposes. It can be seen that journey planner apps were used more often for business trips, trips to appointments or leisure trips than for commuting trips or trips to run errands. For comparing the results of PLB and PLSC, two-tailed t-tests were conducted. After correcting for multiple comparisons problem with the Holm-Bonferroni method (Holm, 1979), a significant difference between the groups for trips to run errands was found ($p = .009$, $d = 0.43$).
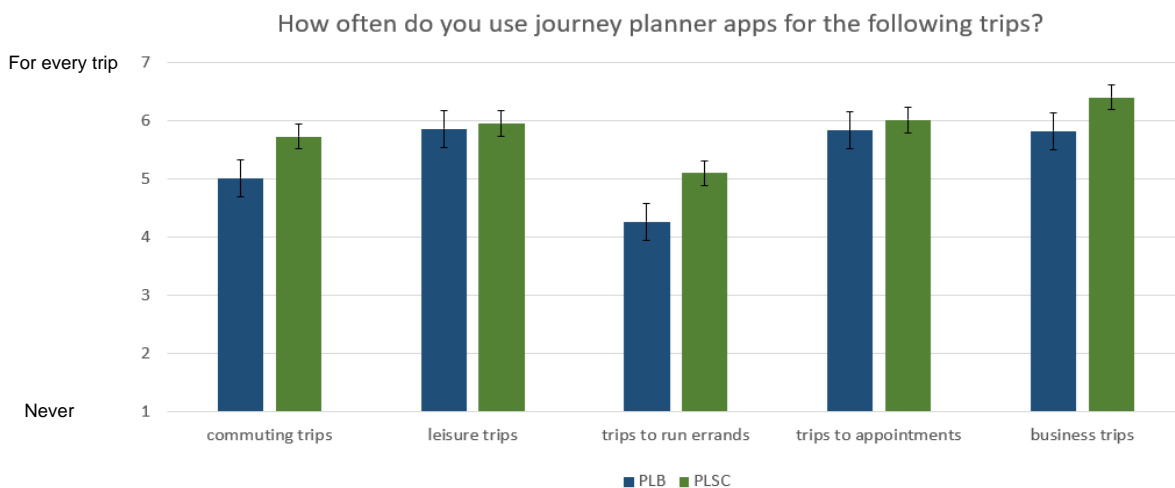
Figure 1 – Mean and *SE* of app usage for different trip purposes

For the timing of the app usage, participants stated, when they normally use journey planner apps for planning a trip. Table 2 shows the results.

**Table 2 – Timing of usage of journey planner apps for different trip purposes***

	Less than 10 minutes prior to the trip		10-30 minutes prior to the trip		30 minutes – 1 hour prior to the trip		1-2 hours prior to the trip		More than 2 hours prior to the trip		More than 24 hours prior to the trip	
	PLB	PLSC	PLB	PLSC	PLB	PLSC	PLB	PLSC	PLB	PLSC	PLB	PLSC
Commuting	32.9%	26.9%	32.9%	28.6%	22.4%	21.0%	5.9%	10.9%	17.6%	11.8%	12.9%	11.8%
Leisure	20.0%	22.7%	31.8%	28.6%	38.8%	24.4%	23.5%	15.1%	20.0%	16.8%	20.0%	21.8%
Run errands	31.8%	23.5%	32.9%	20.2%	18.8%	14.3%	7.1%	8.4%	4.6%	8.4%	5.9%	1.7%
Appointments	12.9%	14.3%	21.2%	13.4%	36.5%	23.5%	24.7%	13.4%	27.1%	19.3%	27.1%	24.4%
Business	10.6%	9.2%	11.8%	10.1%	10.6%	11.8%	11.8%	10.9%	16.5%	10.9%	41.2%	35.3%

*Multiple answers were possible, PLB = people living in Berlin, PLSC = people living in smaller cities

More than 60% of PLB and 40-50% of PLSC planned their commuting trips and trips to run errands only 30 minutes or less before the trip while connections for business trips and trips to appointments were checked by the majority of PLB and PLSC more than 24 hours in advance. PLSC plan their trips slightly earlier than PLB.

3.2 Perceived Usefulness of information on CU

In terms of the perceived usefulness of information on CU, a moderate to high approval of the statement "information on CU is useful for me" was found ($M = 3.52$, $SD = 1.18$). No differences between low (less than once a week) and high (more than once a week) frequent PT users were found. Comparisons between PLB ($M = 3.61$, $SD = 1.20$) and PLSC ($M = 3.44$, $SD = 1.16$) also showed no differences. Means and standard errors of the rating for different trip purposes are shown in Figure 2.
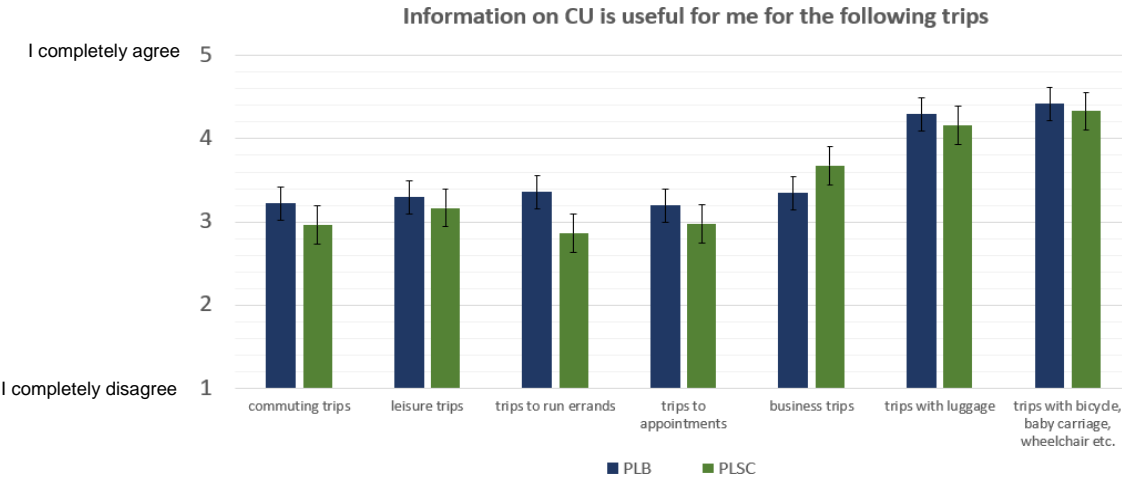
Figure 2 – Mean and *SE* of the perceived usefulness of information on CU for different trip purposes

Information on capacity utilization for passengers: Useful for passengers?

Information on CU was rated equally useful for different trip purposes. Only for trips with luggage, bicycle, baby carriage, etc., it was rated more useful. Differences between PLB and PLSC were found for trips to run errands ($p = 0.010$, $d = 0.41$).

Regarding the trip duration, participants were asked to evaluate the aforementioned statement for eight different durations (Figure 3). Results of a one-way repeated measures analysis of variance (ANOVA) showed a strong significant main effect for PLB ($F = 113.85$, $p < .001$) and PLSC ($F = 179.07$, $p < .001$). After correcting with Holm-Bonferroni method, significant differences between PLB and PLSC with moderate to high effect sizes were found for all trip durations except "41-60 minutes" and "> 60 minutes" with higher values for PLB.
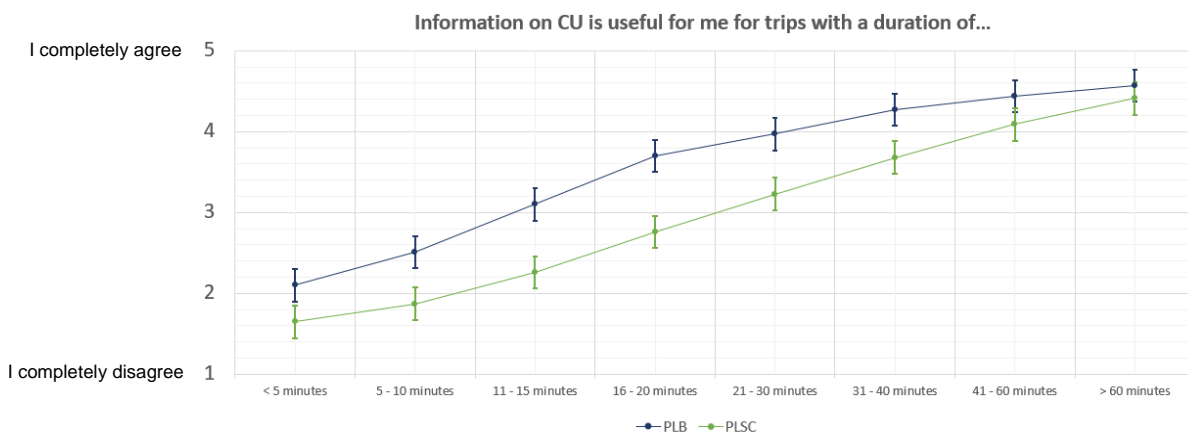

Figure 3 – Mean and SE of the perceived usefulness of information on CU depending on trip duration

In terms of service frequency, participants rated the perceived usefulness (Figure 4). A one-way repeated measure ANOVA was conducted showing a significant main effect for PLB ($F = 8.68$, $p = .002$) and PLSC ($F = 44.82$, $p < .001$). After correcting with Holm-Bonferroni method, significant differences between PLB and PLSC were found for "every 2-3 minutes" ($p = .019$, $d = 0.35$), "every 4-5 minutes" ($p = .014$, $d = 0.37$) and "every 6-10 minutes" ($p < .001$, $d = 0.49$).
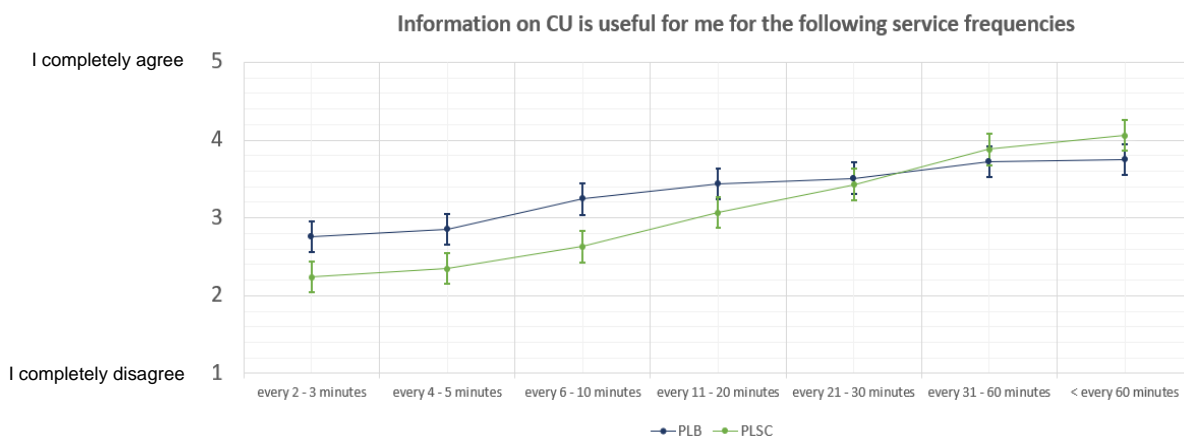

Figure 4 – Mean and SE of the perceived usefulness of information on CU depending on service frequency

Finally, participants were asked when they would need information on CU for different trip purposes. For commuting trips, leisure trips or trips to run errands, it is sufficient for most of the participants when the information is provided 10-30 minutes or even less in advance. For business trips, trips with luggage or trips with a wheelchair, bicycle etc. the information is needed more than 24 hours in advance. This is consistent with the results of the use journey planner apps. Large differences in the required timing of ICU can be found between PLB and PLSC. Over 60% of PLB need the information for commuting trips and trips to run errands less than 30 minutes before a trip. Over 60% of PLSC require the same information more than 30 minutes in advance. On the other hand, business trips or trips with luggage are planned more than 2 hours prior to the trip by only 30-40% of PLB, while more than 60% of PLSC need the information for these trips more than 2 or even more than 24 hours in advance.

Table 3 – Required timing of the provision of information on CU for different trip purposes

	Less than 10 minutes prior to the trip		10-30 minutes prior to the trip		30 minutes - 1 hour prior to the trip		1-2 hours prior to the trip		More than 2 hours prior to the trip		More than 24 hours prior to the trip	
	PLB	PLSC	PLB	PLSC	PLB	PLSC	PLB	PLSC	PLB	PLSC	PLB	PLSC
Commuting	17.6%	8.0%	41.1%	22.7%	17.6%	25.3%	11.8%	16.0%	2.9%	14.7%	2.9%	13.3%
Leisure	18.6%	4.2%	34.3%	31.6%	28.6%	22.1%	17.1%	15.8%	0%	14.7%	1.4%	11.6%
Run errands	23.5%	13.3%	42.6%	33.3%	16.2%	21.3%	10.3%	17.3%	4.4%	12.0%	2.9%	2.7%
Appointments	12.7%	7.1%	38.0%	14.1%	23.9%	27.1%	14.1%	24.7%	7.0%	15.3%	4.2%	11.8%
Business	6.1%	6.9%	28.6%	5.6%	16.3%	9.7%	16.3%	16.7%	6.1%	20.8%	26.5%	40.3%
Luggage	3.9%	3.1%	18.4%	6.1%	19.7%	10.2%	17.1%	15.3%	13.2%	19.4%	27.6%	45.9%
Wheelchair, bicycle etc.	3.2%	3.9%	14.5%	7.8%	24.2%	14.3%	24.2%	14.3%	9.7%	22.1%	24.2%	37.7%

PLB = People living in Berlin, PLSC = People living in smaller cities

4. Discussion

4.1 Conclusion

An online survey was conducted in order to gain more insight on the use of journey planner apps among public transport users. In particular, the frequency and timing of app use for different trip purposes were investigated. In addition, the perceived usefulness of information on capacity utilization depending on trip purpose was analyzed. As level of service differs between metropoles, such as Berlin, and smaller cities, comparisons between these two groups were administered. Results showed differences in frequency and timing of the use of journey planner apps depending on the trip purpose. People from a metropole (i.e. Berlin) use journey planner apps less often than people from smaller

cities. Trip purpose, duration of the trip, and service frequency have an influence on the perceived usefulness of information on CU.

Overall, PLB and PLSC rated information on capacity utilization as useful. The information was perceived as more useful when travelling with luggage, bicycle, wheelchair, stroller, etc. Regardless of where people live, trip-specific factors may play a significant role in how useful the information is perceived. Nonetheless, results of service frequency also revealed differences in the perceived usefulness between PLB and PLSC. The information was significantly more important for PLB for service frequencies between two and ten minutes. The differences may result from the fact that service frequencies in smaller cities is generally not between two and ten minutes and are more likely to be operated in a less frequent manner. When the frequency of service is greater than every 30 minutes, PLSC perceive the information as slightly more useful as this service level may be the more common one in the area. The majority of PLSC also indicated (especially for commuting and running errands) that the information on CU is most useful more than 30 minutes in advance while the majority of PLB indicated the opposite. In general, when service frequency is between two and ten minutes, a delay or train cancellation does not affect the connection as it would when the train only runs every 30 minutes.

People from a metropolitan area, such as Berlin, use journey planning apps differently than people from smaller cities. It seems that because of the high service frequency, PLB do not need to use journey planner apps as often and as in advance as PLSC. Depending on where people live (i.e. frequency of service), the information is required at different points in time. At the moment, it is unclear whether passengers will use the information and choose a less crowded connection or whether the information is just used to be informed about upcoming travel experience. Further personal preferences (such as wanting a seat) and other factors need to be identified in order to provide relevant personal information that will motivate people to choose alternative routes.

4.2 Limitations

The mean age of our sample is ten years younger than the mean age of the German population resulting in a bias. Groups with a lower digital literacy, such as older persons, were less likely to participate in the survey. Therefore, little is known about older persons' needs with regard to information on capacity utilization as they may acquire such information further in advance and may need another device apart from a cell phone for receiving this information. In addition to providing surveys online, also offline versions need to be made available and groups with lower digital literacy acquired specifically. In addition, we did not ask participants whether they have any (permanent) physical or cognitive impairments/disabilities. It is also expected that persons with cognitive and/or physical impairments/disabilities may have different needs for the information on utilization rates. In order to design information on capacity utilization accessible and inclusive, needs and requirement of persons with special needs need to be collected and considered in the design and implementation process.

4.3 Outlook

Apart from studying the needs and requirements of persons with special needs, future research needs to investigate whether and to what extent people are willing to take a different connection that may be to another time, will take longer or will include more changes based on information on CU. This may depend on the trust in the accuracy of the information. It is expected that the point in time at which the prognosis was calculated has an effect on how reliable the information is perceived and whether people are willing to change their route. The general importance of the level of capacity utilization for passengers in comparison to other factors such as travel time or travel costs is also relevant. The effect of different levels of crowding, price categories, and trip durations on route choice behaviour of passengers may also be investigated. In addition to investigating whether and how passengers can be motivated to change their route choice, other strategies reducing the problem of overcrowded public transportation may be addressed. An idea is to inform passengers directly at the platform about the crowding levels of the oncoming train and to lead them to the doors with fewer passenger traffic. In this case real-time, crowding information is a promising way to optimize boarding and alighting and may result in an optimal distribution of passengers inside the vehicle.

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