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Urban Context and Travel Experience Events: An Exploratory Comparison of Two German Cities

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ABSTRACT

The presented study investigates associations between events influencing public transportation experience in both urban (Hamburg) and rural (Tuttlingen) areas in Germany, with the aim of identifying events associated with travel experience, which may in turn influence travel behavior. Using a mobile application, 21 participants in Tuttlingen and 70 participants in Hamburg tracked everyday trips, providing real-time evaluations of travel experiences along with situational data. Multi-level regression analyses were applied to assess associations of events such as punctuality, capacity offer, information about public transportation and others and the ontrip experience. Results indicate that a sufficient public transportation capacity offer shows the strongest positive association in Tuttlingen, whereas a lack of punctuality and low personal well-being show the strongest negative association. In Hamburg, a lack of punctuality and a negative information event seem to have the largest impacts. These findings provide a basis for prioritizing measures to be tested in local public transportation.

Keywords: Public transportation, Travel experience, Experience sampling method, Sustainable behavior

INTRODUCTION

The climate crisis is among the most pressing societal and environmental challenges of the twenty-first century. The European Climate Law establishes the objectives of achieving climate neutrality by 2050 and reducing greenhouse gas emissions by at least 55% by 2030 (European Parliament and Council, 2021). However, projections based on current policies indicate a reduction of only 47% (European Environment Agency, 2025), highlighting the need for more ambitious measures across all sectors. Including international aviation and shipping, transport accounted for 31% of European Union emissions in 2023 and remained a major source of greenhouse gases despite improvements in vehicle efficiency (European Environment Agency, 2025). Policies that restrict private vehicles and improve sustainable alternatives may encourage a transition towards public transport (Banister, 2008; Yannis and Michelaraki, 2024).

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In addition to structural policies, travel behaviour may be influenced by the quality of the travel experience. According to the travel mode choice cycle proposed by De Vos et al. (2021), satisfying experiences can strengthen favorable attitudes towards a transport mode and increase the likelihood of its future use, whereas unpleasant experiences may have the opposite effect. Lim et al. (2024) describe within-trip subjective experiences as passengers' momentary cognitive and emotional responses to travel situations. These experiences contribute to overall travel satisfaction and may, over time, shape travel mode-related attitudes and intentions. Improving the within-trip experience may therefore support the long-term attractiveness of public transport, although the present study examines momentary experience rather than subsequent mode choice.

Public transport satisfaction reflects the relationship between passengers' overall experience and their prior expectations (Morfoulaki et al., 2010). Identifying events that create discrepancies between expectations and experience is therefore important for understanding passengers' evaluations. Previous research has associated satisfaction particularly with cleanliness, comfort, service quality, safety, and punctuality (Van Lierop et al., 2018). Susilo and Cats (2014) additionally identified ease of transfer, station environment, and onboard comfort as influential components of door-to-door travel satisfaction, while also observing differences between passenger groups. Perceived safety, service frequency, and reliability are likewise important predictors of perceived accessibility because they reduce uncertainty and increase passengers' flexibility and temporal autonomy (Lättman et al., 2016). Accessibility is also related to subjective well-being, as the ability to reach everyday activities facilitates social participation and inclusion (De Vos et al., 2021; Olsson et al., 2013).

Particularly positive or negative encounters may exert a disproportionate influence on how journeys are evaluated and remembered. Such encounters are commonly described as critical incidents (Allen et al., 2020). Research on service experiences suggests that these incidents can substantially shape remembered evaluations and subsequent satisfaction (Bitner et al., 1994; Friman, 2004; Gremler, 2004). Together, these findings demonstrate that travel satisfaction is shaped by multiple service-related and contextual events. However, most studies examine overall or retrospective satisfaction, while less is known about how individual events are associated with momentary experience during a journey.

The relevance of these events may also depend on the spatial and structural context. Urban density and city size influence the relative attractiveness of transport modes (Liao et al., 2020). In dense urban areas, comparatively short distances and extensive public transport networks can reduce the time advantage of private cars. In smaller towns and rural areas, longer distances, lower service frequencies, and more limited network coverage often make private vehicles more convenient. Such conditions may affect both the events passengers encounter and how they evaluate them. Although within-trip experience and public transport satisfaction have been studied extensively in urban settings (De Vos et al., 2021; Lim et al., 2024; Susilo and Cats, 2014), rural and less densely populated contexts remain comparatively under-researched.

Understanding these contextual differences is particularly relevant because many rural mobility concepts depend on the voluntary participation of residents who retain access to private cars. For public transport to represent a viable alternative, it must offer experiences that encourage repeated use. However, it remains unclear whether the events associated with within-trip experience differ between urban and rural settings. Evidence on these patterns could help transport providers identify context-specific priorities and assess whether measures developed in metropolitan areas are transferable to less densely populated regions.

This study addresses this gap by examining Hamburg, a major metropolitan area, and Tuttlingen, a smaller town situated within a predominantly rural district. The comparison provides exploratory evidence on how within-trip events are associated with public transport experience in two contrasting spatial contexts. It addresses the following research questions:

1. Which events influence travel experience in Hamburg and Tuttlingen?
2. Does the influence of these events differ between the cities?

METHOD

Participants were recruited by using social media channels and via advertising spaces in public transportation vehicles in Hamburg. This method allowed to recruit regular public transportation users and car commuters to collect a more differentiated opinion. They were then referred to a recruitment questionnaire, which included the contact details and demographic data. Participants had to be 18 years or older and were required to have access to an Android mobile phone.

Sample

Overall $N = 21$ participants with a mean age of 29.24 years ($SD = 13.55$) took part in Tuttlingen. Gender distribution was almost balanced, with nine female and eleven male participants. One participant chose not to answer this question. 18 participants in Tuttlingen stated using public transportation regularly multiple times a week or daily while three participants use it once a week or once a month. The revised study design, described in the following chapter, resulted in Hamburg in 34 male, 35 female and one non-binary participant ($N = 70$) with a mean age of $M = 35.93$ ($SD = 12.96$). They reported their public transportation usage as follows: 2× once a week, 25× multiple times a week and 43× daily. Written informed consent was obtained from all participants.

Study Procedure

This study consisted of two different data acquisition locations: Tuttlingen, a small city in southern Germany, has around 38000 inhabitants and serves as the economic center of its district. Located in the state of Baden-Württemberg on the upper Danube river, Tuttlingen is internationally known as a hub of the medical technology industry, often referred to as the world

capital of medical technology. The city is connected to regional and long-distance transport networks, with rail services linking it to larger cities and a local public transport system consisting mainly of buses. The second study location was Hamburg, Germany's second largest city. It has 1.8 million inhabitants and a metropolitan region of around 5.5 million. Located in the country's north on the river Elbe, Hamburg is a major economic and transport hub. The city has a public transport network operated under the Hamburger Verkehrsverbund (HVV), including subway (U-Bahn), suburban rail (S-Bahn), buses, and ferries.

The study design of this work has been previously tested and further developed (Bosch et al., 2025, 2026). By downloading the institute's research app on their Android smartphone, participants were instructed to track six trips with a minimum duration of 15 minutes. During their trip, they were reminded by vibration of their phone to complete a questionnaire about the current situation every five minutes. When they reached their final destination, an additional questionnaire regarding the overall trip was completed. The study was concluded with a retrospective questionnaire of the entire participation. This included stressors, positive and negative aspects of traveling, used apps, and the potential willingness to share data for personalized routing. The study manager verified the number of trips and their completeness before paying out money as an incentive. Overall participants could get up to 70€ which consisted of 20€ for the first three trips, 30€ after completion of all six trips, 10€ if at least 95% of questionnaires were answered and ten times 1€ for each additional trip. This study procedure has been approved by the ethics committee of the German Aerospace Center (reference number 4/25).

Collected Data and Measures

Demographic data was collected through the recruitment questionnaire. The institute's research app recorded public transportation schedule data, actual routes traveled, including the start and end point and the used transport modes. Additionally, questionnaire evaluation data was saved with corresponding pseudonymous login data. The data was prepared before conducting the statistical analysis. First, all data was combined and filtered. For the dataset of Tuttlingen, trips with no start or destination in the district of Tuttlingen were sorted out. Evaluations during the trip (called 'ontrip' throughout the paper) were assigned to the associated post-trip evaluation and events. The chosen influencing events in the questionnaire are based on a literature review and identified by analyzing complaints issued to the Hamburg Transport Association as well as qualitative and statistical analysis of previous studies: The ontrip questionnaire contained the following items which were previously identified by using confirmatory factor analysis (manuscript under preparation). Items 1 to 3 were answered with a 5-point Likert-scale:

1. The journey at the moment is 1 (miserable) to 5 (excellent).
2. For achieving my goals, this journey is 1 (a hindrance) to 5 (favorable).
3. Based on my previous experience with traveling this journey is 1 (below average) to 5 (above average).

Items 4 to 12 could be answered *positive* or *negative*, no answer resulted in *neutral*. Item 13 contains an optional free text answer.

4. Punctuality and transfers, e.g. connection made or transport departed too early (positive | negative, not completed = neutral)
5. Fellow passengers, e.g. pleasant fellow passengers or disruptive people (positive | negative, not completed = neutral)
6. Capacity utilization in the transport, e.g. full or plenty of space (positive | negative, not completed = neutral)
7. Driving behavior, e.g. rough or pleasant driving style (positive | nega-tive, not completed = neutral)
8. Infrastructure, e.g. clean means of transport or no weather protection available (positive | negative, not completed = neutral)
9. Information, e.g. alternative routes in case of cancellation or lack of information (positive | negative, not completed = neutral)
10. Well-being, e.g. nice view, music, temperature, or discomfort, need to hurry (positive | negative, not completed = neutral)
11. Staff, e.g. nice or unfriendly ticket inspector (positive | negative, not completed = neutral)
12. Capacity, e.g. good or poor frequency (positive | negative, not completed = neutral)
13. Other [free text]

Collected data was analyzed with multi-level regressions. For the analysis, capacity utilization (item 6) and capacity (item 12) were merged into a single event variable, capacity offer, as both items refer to capacity-related conditions. In Tuttlingen 1876 ontrip evaluations were collected whereas Hamburg resulted in 8188. The mean ontrip experience was defined by calculating the mean value of items 1 to 3 and predicted by the events of items 4 to 12 as independent variables. A random intercept accounted for interpersonal differences between participants. No random slope or interaction effects were modeled.

RESULTS

The following chapter presents a visual overview of the data and the results of each regression. The boxplots (Figure 1) show differences in participants' mean ontrip experience across positive and negative events in Hamburg and Tuttlingen. For the positive events, the interquartile ranges (IQRs) are similar between cities, though Hamburg shows a higher median per event and general mean value, while Tuttlingen's mean is slightly lower. Negative events display much more variability, with IQRs differing markedly between cities and events, particularly in Hamburg. This can be seen in comparison to the events of information, capacity, service provision and staff, where medians are notably low, especially regarding staff and punctuality. Overall, Hamburg has higher mean ratings for positive events, whereas negative events reduce the mean by nearly one point. Tuttlingen, by contrast, shows less difference in the mean ratings between positive and negative events.

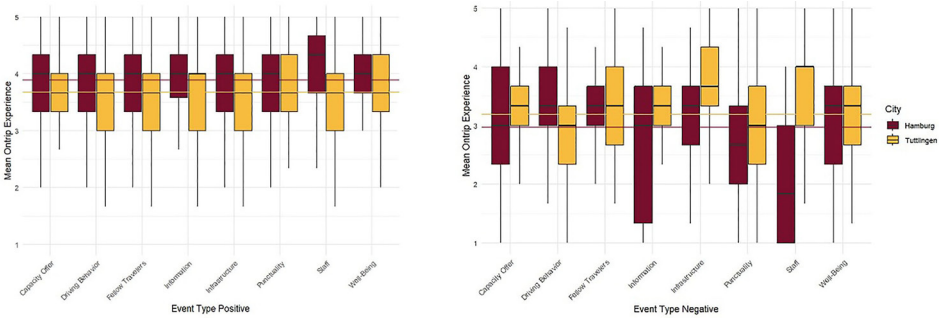


Figure 1: Descriptive visualization of the mean ontrip experience per positive (left) and negative (right) event for the cities Hamburg and Tuttlingen. The horizontal lines show the mean value per city for all positive and all negative events. The outliers are hidden.

Multi-level regression models with an AR(1) correlation structure were fitted to predict mean ontrip experience for each city. Residuals of the initial model without autocorrelation show strong positive autocorrelation (*Durbin – Watson* = 0.26, $p \leq .001$), so a first-order autoregressive structure (AR(1)$\phi = 0.90$) was included. ACF and PACF plots of normalized residuals indicated that AR(1) adequately captures temporal dependence. A series of model comparisons were conducted using likelihood-ratio tests and information criteria (AIC and BIC). If the likelihood-ratio test was non-significant, the more conservative model was preferred, particularly when supported by BIC. This approach was chosen due to the large sample size and the risk of detecting statistically significant but practically negligible effects. Table 1 presents the results of the fitted models for Tuttlingen and Hamburg. Tuttlingen's model shows the lowest AIC (821.08) and BIC (920.75) for the compared models with the excluded event *staff*. Including all collected events would result in a worse model fit (ΔBIC = 14.20) with the likelihood-ratio being non-significant, $\chi^2(2) = 0.87, p = .646$. The model for Hamburg includes all event-types with an AIC = 2088.50 and BIC = 2228.71 and uses an AR(1) correction as well. Excluding the event staff would result in a worse model fit (ΔBIC = 4.95) with a significant likelihood-ratio, $\chi^2(2) = 22.44, p \leq .001$.

Table 1: Results of multi-level regression for Tuttlingen (TUT; left) and Hamburg (HH; right), **significant events are highlighted**. Neutral served as reference for the categorical event variables. $df_{TUT} = 1842$; $df_{HH} = 8101$.

Events		β_{TUT}	t_{TUT}	p_{TUT}	β_{HH}	t_{HH}	p_{HH}
Intercept		3.17	28.33	**≤ .001**	3.36	76.01	**≤ .001**
Driving Behavior	negative	0.07	1.13	.258	–0.07	–2.33	**.020**
	positive	0.18	4.46	**≤ .001**	0.13	7.75	**≤ .001**
Information	negative	–0.22	–3.67	**≤ .001**	–0.30	–11.34	**≤ .001**
	positive	–0.23	–4.44	**≤ .001**	0.08	4.26	**≤ .001**
Fellow passengers	negative	–0.17	–3.78	**≤ .001**	–0.13	–7.81	**≤ .001**
	positive	0.06	1.54	.123	0.07	4.20	**≤ .001**

(Continued)

Table 1: Continued.

Events		β_{TUT}	t_{TUT}	p_{TUT}	β_{HH}	t_{HH}	p_{HH}
Personal well-being	negative	–0.23	–5.14	≤ **.001**	–0.13	–7.12	≤ **.001**
	positive	0.06	1.66	.097	0.15	8.34	≤ **.001**
Capacity offer	negative	–0.09	–2.02	**.044**	–0.15	–6.34	≤ **.001**
	positive	0.31	6.15	≤ **.001**	0.14	7.36	≤ **.001**
Staff	negative	–	–	–	–0.15	–2.66	.008
	positive	–	–	–	0.07	3.75	≤ **.001**
Punctuality	negative	–0.26	–5.26	≤ **.001**	–0.50	–21.38	≤ **.001**
	positive	0.17	3.67	≤ **.001**	0.07	3.73	≤ **.001**
Infrastructure	negative	0.09	1.74	.082	–0.07	–2.79	.005
	positive	0.20	4.21	≤ **.001**	0.12	6.21	≤ **.001**

DISCUSSION

This study examined how momentary within-trip events were associated with mean ontrip experience in urban Hamburg and rural Tuttlingen. Regarding RQ1, the multilevel models indicate that most predefined event categories were associated with experience ratings in both locations, although the direction and magnitude of the coefficients varied. Because the events were self-reported and the analysis was observational, these coefficients should be interpreted as associations rather than causal effects.

In Tuttlingen, a positive capacity offer showed the largest positive coefficient relative to a neutral rating (β = 0.31). Negative punctuality (β = –0.26), negative personal well-being (β = –0.23), and both positive and negative information ratings (β = –0.23 and β = –0.22, respectively) showed the largest negative coefficients. Positive driving behavior and infrastructure were also associated with better experience ratings, whereas negative driving behavior, positive fellowpassenger ratings, positive well-being, and negative infrastructure were not statistically distinguishable from the neutral reference. Staff was excluded from the preferred Tuttlingen model because its inclusion did not improve model fit. The negative coefficient for information rated as positive is unexpected and may reflect ambiguity in how participants interpreted this event category; it should therefore not be treated as evidence that information itself worsens the travel experience.

In Hamburg, all event coefficients retained in the model were statistically significant. Negative punctuality had the largest negative coefficient (β = –0.50), followed by negative information (β = –0.30). These patterns are consistent with the possibility that delays and inadequate disruption information are especially salient in a dense network in which travelers coordinate transfers and rely on timely alternatives; however, this mechanism was not measured directly. Positive personal well-being had the largest positive point estimate (β = 0.15), closely followed by a positive capacity offer (β = 0.14), positive driving behavior (β = 0.13), and positive infrastructure (β = 0.12). The small differences among these positive coefficients do not support a strong ranking without confidence intervals.

Regarding RQ2, the two coefficient profiles suggest context-dependent patterns but do not establish statistically significant differences between the cities. The predicted baseline experience under neutral event ratings was slightly higher in Hamburg (3.36) than in Tuttlingen (3.17), and the descriptive contrast between all-positive and all-negative event ratings was larger in Hamburg ($\Delta = 0.92$) than in Tuttlingen ($\Delta = 0.49$). Moreover, negative punctuality and information were more prominent in Hamburg, whereas positive capacity conditions were most prominent in Tuttlingen. Nevertheless, the models were estimated separately and included no city-by-event interaction terms. Consequently, the study provides descriptive evidence of different patterns, not a formal test that individual event effects differ between locations. The contrast also cannot be attributed to urbanity alone, because city context is inseparable here from network characteristics and sample composition.

Across both locations, the recurring relevance of punctuality, information, capacity, and personal well-being is consistent with previous research on public transport satisfaction and within-trip experience (Morfoulaki et al., 2010; Van Lierop et al., 2018; De Vos et al., 2021; Lim et al., 2024). The comparatively large negative coefficients for some adverse events also accord with research on critical incidents, which emphasizes the salience of particularly dissatisfying service encounters (Bitner et al., 1994; Friman, 2004; Gremler, 2004; Allen et al., 2020). At the same time, statistical significance should not be equated with practical importance, particularly for Hamburg's 8,188 evaluations. The unequal samples, the small Tuttlingen participant group, and the predominance of regular public transport users further limit generalization to rural residents who rarely or never use public transport.

The findings therefore suggest provisional, context-sensitive priorities: punctuality and disruption of information in Hamburg and capacity-related conditions in Tuttlingen. These patterns should be treated as hypotheses for service design rather than evidence that a specific intervention will improve satisfaction. Transport providers could use them to prioritize local testing while retaining system-wide attention to punctuality, information, capacity, and passenger well-being. The proposed pathway from improved within-trip experience to mode choice, social inclusion, and lower emissions remains theoretically plausible (De Vos et al., 2021) but was not tested here; policy effects therefore require longitudinal or intervention research.

LIMITATIONS AND FUTURE RESEARCH

Several limitations constrain interpretation. The study compared one metropolitan and one rural case with unequal participant samples (Hamburg: $N = 70$; Tuttlingen: $N = 21$) and numbers of momentary evaluations (8188 and 1876, respectively). Location is therefore confounded with transport networks, service provision, and sample composition, so the findings cannot be generalized to urban and rural public transport as a whole. The small Tuttlingen participant sample limits between-person inference, whereas numerous repeated evaluations may yield statistical significance for small effects. Random intercepts and an AR(1) structure accounted for some dependence, but random

slopes and city-by-event interactions were not modeled. Consequently, RQ2 remains descriptive; a combined model with interaction terms and confidence intervals is needed to test location differences.

Recruitment through advertisements and social media, the Android-phone requirement, and the monetary incentive may have introduced selection bias. Both samples were comparatively young, and of 21 Tuttlingen participants already used public transport regularly. Older adults, people with lower digital confidence, occasional or non-users, and car-dependent residents may therefore be underrepresented. This limits conclusions about mode change. Future multisite studies should recruit larger, more heterogeneous samples stratified by age, car access, and current transport use.

Events and ontrip experience were self-reported in the same questionnaire; their associations may partly reflect common response tendencies or momentary affect and cannot establish causality. An unanswered event item was coded as neutral, although it could mean that no event occurred, it was not noticed, or the item was skipped. The unexpected negative coefficient for positively rated information in Tuttlingen also suggests inconsistent interpretation. Clear, mutually exclusive definitions and consistent terminology for vehicle occupancy and service frequency should be validated. Objective operational data and qualitative accounts could further distinguish service conditions from individual interpretations.

Finally, repeated prompts may have altered attention to momentary events, but this reactivity was not assessed. Momentary ratings were not linked to the collected post-trip evaluations, preventing conclusions about retrospective satisfaction or peak-end effects (Kahneman et al., 1993). Future research should analyze both levels jointly and examine reliability, ease of transfer, and group-specific needs.

CONCLUSION

This exploratory study addressed RQ1 by showing that self-reported within-trip events were associated with momentary public transport experience in both locations. In Tuttlingen, a positive capacity offer had the largest positive coefficient, whereas negative punctuality, well-being, and information had the largest negative coefficients. In Hamburg, negative punctuality and negative information were most prominent. Across both cases, punctuality, information, capacity, and personal well-being emerged as recurring correlates of experience.

Regarding RQ2, the coefficient profiles differed descriptively, but the separate models do not demonstrate statistically significant differences between the cities or show that urbanity caused the observed patterns. The findings therefore provide context-specific hypotheses rather than transferable policy prescriptions: punctuality and disruption information warrant local testing in Hamburg, while capacity-related conditions warrant testing in Tuttlingen. Stronger conclusions require multisite samples, direct city-by-event comparisons, and longitudinal or intervention studies. Effects on future mode choice, social inclusion, and emissions remain important but untested outcomes.

DECLARING OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

Statement: During the preparation of this work, the authors used ChatGPT to improve wording and optimize the readability of the text. DeepL was used to translate individual terms and passages, which were checked against specialist literature. DeepL Write was used to refine stylistic and linguistic nuances. Zotero was used to manage and organize the literature sources used throughout the manuscript, including the references. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the published article.

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CRediT roles: Conceptualization, Data curation, Formal analysis: MG and EB; Funding acquisition: EB; Investigation, Methodology: MG and EB; Project administration: EB; Validation: MG and EB; Visualization: MG; Writing – original draft: MG; Writing – review and editing: MG and EB; Supervision: EB.

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