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Page: 58 - 65
Short Paper
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Development of a Standardized, Interdisciplinary Approach for Evaluating the Impact of Infrastructural Interventions on Sustainable Mobility

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Abstract

There is currently no standardized methodology for evaluating the impacts of road infrastructure measures on different road-user groups or the mobility system. In the POSITIM project, we developed a standardized methodology that allows us to evaluate systemic and personal effects of infrastructural interventions. The evaluation criteria were safety, stress, smoothness, acceptance of the intervention, and mobility behaviour.

Keywords:

mixed-methods, human sensing, GIS, qualitative interviews, evaluation, planning

1 Background and motivation

The design or redesign of public spaces and the improvement of conditions for cycling and walking are essential prerequisites to promote sustainable and active forms of mobility, and thus for the sustainable development of cities (Banister, 2007). To date, there is no standardized methodology for evaluating the impact of road infrastructure measures on different road-user groups or for determining which infrastructure changes lead to improvements for active mobility. Thus, there is a lack of fundamental evidence for planning and decision-making processes as well as for the allocation of budgets in the mobility sector.

In the POSITIM project, we developed a standardized methodology that allows us to evaluate systemic and personal effects of infrastructural interventions. The evaluation criteria were safety, stress, smoothness of (bicycle) traffic flow, acceptance of the intervention, and mobility behaviour. In developing the methodology, we combined approaches from different disciplines: geoinformatics, human sensory analysis, traffic planning and sociology.

2 Methodology

2.1 Pre-post evaluation

To generate a baseline against which to compare the effects of a measure, including changes in the users' experience of the road space, the POSITIM project applies pre- and post-evaluations. The pre-analysis takes place before any implementation of the measures, the post-analysis a few weeks after the intervention. Identical methods are used in both the pre- and post-analyses in order to clearly identify the impact of measures.

2.2 Methods

The following methods were used to carry out the evaluation.

Spatial context data

Basic geospatial data are used for morphological analysis and assessment of road infrastructure. Geospatial data are also used to investigate the potential in terms of residential population and road users, and to provide spatial context for various data collected by the study's participants. The spatial context is defined by the built and the natural environments. If this information layer is considered in the analysis, data on weather, traffic state and land use are required. The suitability of infrastructure for cyclists and pedestrians was assessed using models based on road network data, complemented by a digital elevation model and environmental data.

Traffic counts

In the test area, traffic counting data were collected by means of a stationary camera system which can automatically recognize different groups of traffic participants (pedestrians, cyclists, motorized vehicles), while preserving the privacy of road users. The data generated served as input to derive the modal split in the immediate vicinity of the camera.

Lateral distance measurement

Open Bike Sensors (OBS), fixed to participants' bicycles, were used in the field studies to collect lateral distance measurements (distance between participants and other road users or lateral objects) as well as position data. Participants marked overtaking manoeuvres by other vehicles by pressing a button, which was mounted on their handlebars.

Measuring physiological reactions

Human sensor technology enables the measurement of physiological parameters with the help of bio-physiological sensors. Sensors picked up immediate stress reactions by measuring several parameters, including galvanic skin response, skin temperature and heart-rate variability. The physiological stress experiences were given GPS coordinates and time stamps. From the measurement data, we derived moments of stress (MOS) according to the algorithm presented by Kyriakou et al. (2019). As described in Resch et al. (2015(a), 2015(b)), the concept of the person as a sensor makes use of physiological measurements to gain insights into a person's perception of their surroundings in an urban environment.

e-diary smartphone app – perceived, self-reported stress and emotions

Participants used a specially developed app in which they could enter in real time the perceived emotion or stress level, the intensity of the emotion, and the context, such as the particular stress-causing factor in the mobility infrastructure.

Video data

To ground-truth the stress moments, participants recorded videos using action cameras, which were mounted on them at chest-height.

Survey and interviews

A standardized questionnaire was used to collect quantitative data on mobility behaviour, perception of safety and stress, and assessment of the infrastructure regarding their participation as cyclists in the traffic in the test area. The quantitative data enables pre- and post-analysis to be carried out to identify statistically relevant differences between the time before and the time after any intervention.

Guided interviews were also conducted to gain a better understanding of participants' perceptions, their experiences during the test ride, the causes and conditions of their feelings of stress and safety, and their assessment of the infrastructure.

3 Indicators for evaluation

Based on the literature and their practical relevance to the field of transport planning, we applied safety, smoothness, stress, acceptance, and mobility behaviour as criteria for the evaluation.

3.1 Mixed-methods approach

We followed a mixed-methods approach to address the complexity of evaluating safety, stress, smoothness, acceptance and mobility behaviour. 'Mixed methods' refers to the use and linking of qualitative and quantitative data within a research study. The application of a mixed-methods approach has a long tradition in the social sciences, but the joint use of qualitative and quantitative research methods is being increasingly adopted in other disciplines (e.g., Fetters et al., 2020; Preston et al., 2014).

We integrated the various methods, as described below, and linked the information from the different sources. This approach allows us to generalize the impact of infrastructure interventions, understand the significance of these interventions, and to be able to zoom in on details.

3.2 Data integration

The integration of data was effected at two levels.

1st Level: Data that are directly related to each other are combined and subsequently analysed together. This concerns, for example, the combination of the measured physiological stress points with the points of strong emotions gathered from the questionnaires. These data are integrated with each other before analysis, and then evaluated jointly.

2nd Level: Where data from various sources cannot be directly linked, different processing and analysis steps are taken. For example, the indicator 'stress' can be informed by both quantitative human sensor data (e.g. number of physiological measurement points, intensity of perceived stress) and qualitative data (self-reported stress, contextualization of stress in interviews). Integration can be done by linking different sets of quantitative data (e.g. human sensor data, questionnaire data) but also by explaining quantitative data with qualitative data. Spatial and temporal references as well as the user's ID are employed in data linking.

4 Field studies

The pre-post analyses using a mixed-methods approach were based on four use cases: two field studies in the city of Salzburg, one in Nuremberg, and one in Münster. The field studies took place in two phases. In the initial phase, which was carried out before the infrastructure had been redesigned, data collection was carried out using the methods described above, following a standardized implementation protocol. At the time of writing this paper, post-evaluation studies had been conducted for just one test case, namely Ignaz-Rieder-Kai, Salzburg.

The recruitment of participants for the field studies was carried out with the support of the cities in which the tests took place. Various channels were used to disseminate information about the project and the invitation to participate, such as mailings from the city administration, social media posts, and notices in shops. People were sought who cycled in the city and had experience of cycling in mixed traffic in urban areas.

Thirty participants took part in the pre-study for Ignaz-Rieder-Kai, 25 of whom went on to contribute to the post-study, which allowed for the possible effects of changes to the infrastructure to be evaluated. When selecting the participants, we aimed for a balanced gender ratio and a diversity of ages, as these are known to be important characteristics or proxy variables with regard to road safety. The evaluation was conducted using a panel design.

4.1 Salzburg

In Salzburg, two different interventions on the cycling infrastructure were evaluated. The first concerned a centrally located but little used road along the riverside, where a multi-purpose lane (for cycling and motorized vehicles) on one side of the road was converted into a dedicated cycling lane (Ignaz-Rieder-Kai). The second intervention was on the outskirts of Salzburg, where a mixed walking and cycling path was partly widened.

4.2 Münster

In Münster, a two-lane road with cycle lanes in each direction, separated from the motorized transport by traffic dividers, was converted into a cycling street with wider pavements for pedestrians.

4.3 Nuremberg

In Nuremberg, the impact of marking a new multipurpose lane on a busy road was evaluated.

4.4 Procedure for the field studies

The pre-analysis took place on two consecutive days; the test took about one hour for each participant. Participants were introduced to the test and equipped with OBS, heart rate monitor, wristband, first-person camera and smartphone. They cycled along the test route twice in each direction. During the test runs, OBS data, human sensor data, entries in the app on stress perceptions, and video data were collected. Afterwards, the participants completed a questionnaire and took part in a qualitative interview. The post-analysis followed the same procedure.

5 Preliminary and expected results

In what follows, we present preliminary results from the field test at Ignaz-Rieder-Kai. For this study site, pre-post evaluation has already been completed.

5.1 Survey Data

Comparing the two time slices – before and after – shows that participants felt quite safe and relaxed using the Ignaz-Rieder-Kai; they considered the route beautiful and relatively low in car traffic. However, there are still complex and unsafe situations on the route where participants would like to see further improvements. Even greater reduction in car traffic is desirable for participants; 68% of them preferred using the road since it had become reserved for cyclists; 32% found it just as good as before, and nobody liked it less since the intervention. 56% of participants found the road for cyclists safer than the former multi-purpose lanes, and 44% found it just as safe as before. In addition to the descriptive analyses, we applied Wilcoxon signed-rank tests and chi-squared tests but found no significant changes between the two time slices.

5.2 Interview Data

The participants felt fairly safe and relaxed on the Ignaz-Rieder-Kai. They did not notice any major changes to the infrastructure itself. Many of the suggestions for improvement that we collected during the pre-study regarding the infrastructure remained the same in the post-study: the merging of pedestrian, bicycle and car traffic at the intersection was still confusing, due to unclear traffic priorities and traffic routing. Introducing the road for cyclists resulted in participants feeling that car drivers had become more considerate of cyclists, and that the possibility of cyclists riding side by side was a good thing.

5.3 Human Sensing Data

The unclear priorities at the intersection are also reflected in the MOS map (Figure 1). Both objectively measured stress and self-reported incidents from the e-diary app suggest reduced levels of comfort at this particular point.

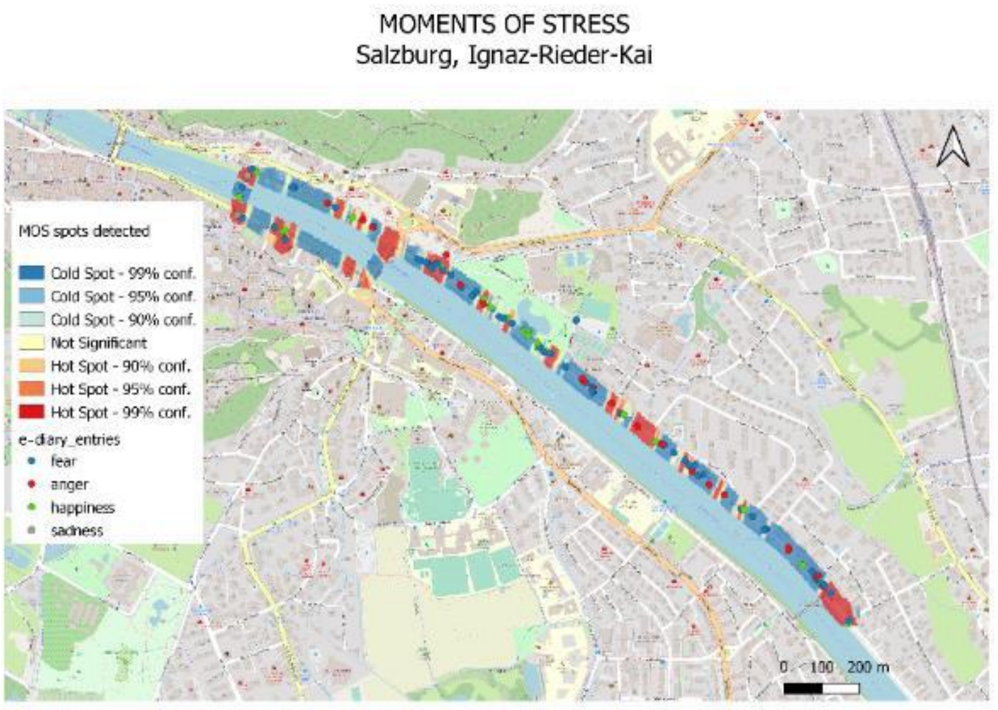

Figure 1: Map showing Moments of Stress

The final results with regard to the evaluation criteria safety, stress, smoothness of bicycle traffic flow, acceptance of intervention and mobility behaviour are still pending, as the data analysis and interpretation have not yet been completed. The final results for Ignaz-Rieder-Kai will be described in a dedicated report.

5.4 Expected future results

A central result will be the definition of an easy-to-implement mixed-methods methodology for the pre-post evaluation of infrastructural interventions. This methodology will make it possible in the future to draw on measures that have already been evaluated and that have proven to be effective in improving safety and reducing stress, have had a positive impact on sustainable mobility behaviour, and have gained acceptance by users.

The results from level-one data integration and those from the second level will be clearly distinguishable from each other. Results based on the first-level data integration will show which of the interventions have had an effect on our defined indicators. The second-level analyses, due to the different methods used, will reveal more in-depth results and advance the integration of the different data – a major scientific advance in the evaluation of measures for active and sustainable forms of mobility. Finally, the results will show the benefit of combining different methods in increasing knowledge.

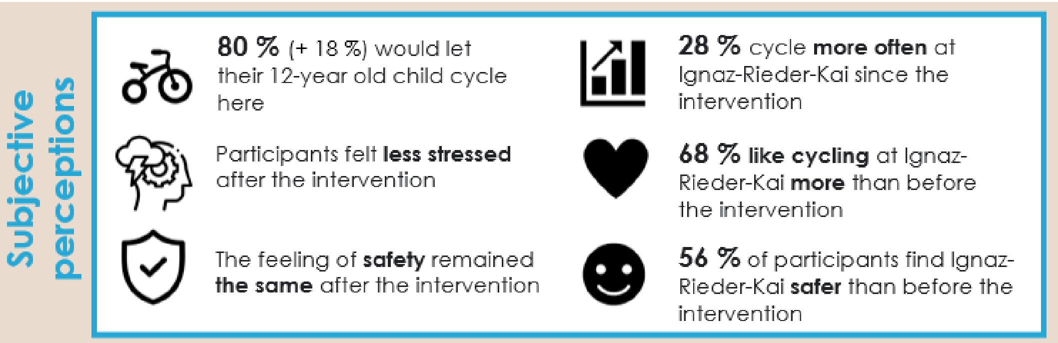

Figure 2: Exemplary results of the evaluation of the intervention on Ignaz-Rieder-Kai

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References

Atzmanstorfer, K., Eitzinger, A., Marin, B. E., Parra Arteaga, A., Gonzalez Quintero, B., & Resl, R. (2016). HCI-Evaluation of the GeoCitizen-reporting App for citizen participation in spatial planning and community management among members of marginalized communities in Cali, Colombia. *GI_Forum*, *1*, 117–132. https://doi.org/10.1553/giscience2016_01_s117

Banister D. (2007). The sustainable mobility paradigm. Transport Policy 15: 73-80.

Christiansen LB, Cerin E, Badland H, et al. (2016). International Comparisons of the Associations between Objective Measures of the Built Environment and Transport-related Walking and Cycling: IPEN Adult Study. J Transp Heal 3:467–478.

Fetters, MD, Molina-Azorin, JF. (2020). Utilizing a Mixed Methods Approach for Conducting Interventional Evaluations. Journal of Mixed Methods Research, 14(2): 131-144

Kyriakou, K., Resch, B., Sagl, G., Petutschnig, A., Werner, C., Niederseer, D., Liedlgruber, M., Wilhelm, F.H., Osborne, T. and Pykett, J. (2019). Detecting Moments of Stress from Measurements of Wearable Physiological Sensors. Sensors, 19(17), pp. 3805, DOI: https://doi.org/10.3390/s19173805.

Preston, B., & Wilson, M. W. (2014). Practicing GIS as Mixed Method: Affordances and Limitations in an Urban Gardening Study. Annals of the Association of American Geographers, 104(3), 510-529. doi:10.1080/00045608.2014.892325

Resch, B., Sudmanns, M., Sagl, G., Summa, A., Zeile, P. and Exner, J.-P. (2015a). Crowdsourcing Physiological Conditions and Subjective Emotions by Coupling Technical and Human Mobile Sensors. GI_Forum - Journal for Geographic Information Science, 3(1), pp. 514-524. DOI: https://doi.org/10.1553/giscience2015s514

Resch, B., Summa, A., Sagl, G., Zeile, P. and Exner, J.-P. (2015b). Urban Emotions - Geo-semantic Emotion Extraction from Technical Sensors, Human Sensors and Crowdsourced Data. In: Gartner, G. and Haosheng Huang (eds.) (2015), Progress in Location-Based Services 2014, Springer International Publishing, Switzerland, pp. 199-212. DOI: https://doi.org/10.1007/978-3-319-11879-6_14.