Cycling is an emission-free and healthy mode of transportation. However, the share of cycling in the modal split is still low. Perceived safety during cycling could be a reason for that. The RouteMeSafe application is developed at Stuttgart University of Applied Sciences with the aim of tackling this issue. A safety routing function is supposed to increase the short-term safety of cycling by showing safe paths for cyclists. Long-term safety is supposed to be increased with the feedback function enabling cyclists to share their evaluation of the cycling infrastructure with the city administration. The safety routing function is currently in the design phase and the feedback function in prototype phase. To develop the application user-friendly, target groups for both functions need to be defined and their expectations considered in the development process. Two studies with infrequent and frequent cyclists have been conducted to do so. Study 1, a user experience study based on a student sample, showed that infrequent cyclists could be a target group for the safety routing function and frequent cyclists could be a target group for the feedback function. The latter was confirmed in study 2, a technology acceptance study based on a sample with frequent cyclists of Stuttgart. Future studies on the application should investigate the long-term technology acceptance of the two groups.
This could help to find out whether both groups can serve as target groups on the long run.

**Keywords**

Target groups · Transportation · Cycling · Safety · Infrastructure · Routing

### 2.1 Introduction

As a means of transport, cycling offers several benefits for citizens of urban areas. It is emission-free and healthy for the user. Well-being and physical and mental health are promoted by cycling (Singleton, 2019). Nevertheless, the share of the bicycle in the modal split in Germany is only 12% (Agora Verkehrswende, 2019). One reason for that could be the negative emotional state experienced during cycling. Cycling is perceived as unsafe by many people (Singleton, 2019). This feeling of danger represents a barrier to cycling (Rérat, 2019). Therefore, city administrations should try to improve perceived cycling safety. In this matter, the cycling infrastructure is an important point of reference because it influences perceived cycling safety significantly (Schmidkunz, Schroth, Zeile and Kias, 2019). To improve the cycling infrastructure in metropolitan regions, the RouteMeSafe application is being developed at the Stuttgart University of Applied Sciences in the project i_city: intelligent city. Hereby, two main goals are pursued: To improve perceived cycling safety in the long run, the application is supposed to provide city administrations with a feedback function on the perceived safety of their cycling infrastructure. This could enable city administrations to implement measures based on the evaluation of the people using the cycling infrastructure. However, the implementation of infrastructure measures often requires a lot of time. Therefore, a safety routing function, which illustrates safe routes for cyclists, is additionally being developed to increase the short-term perceived cycling safety. In a bachelor thesis, supervised by the Departments of Computer Science and Business Psychology, a prototype (available for Android and iOS) of the feedback function was developed. In the prototype, cyclists can enter, view, and evaluate dangerous spots (Fig. 2.1).

The safety routing function is currently still in the conception phase. As a next step in the development process, the i_city development team decided to define the target groups for the RouteMeSafe application and to include their expectations in the further development process. Although it might seem logical to address as many users as possible with a product, a different approach is recommended in the literature on user-centered product development. According to Cooper (2004), no one product can satisfy all potential users sufficiently. It is therefore recommended to rather focus on the complete satisfaction of a subgroup of potential users instead of trying to satisfy all potential users only partially. In the case of the RouteMeSafe application, there is a need for users who generate data (enter/rate dangerous spots) with the feedback function and use the security routing function. Users who generate data are important for filling the application’s database, which provides the foundation for the feedback and safety routing functions. The size and quality of the
database will most likely play a part in how reliably the functions work. Furthermore, a large and high-quality database will make the application more attractive for city administrations because they can thereby generate valid feedback on their infrastructure measures. Users who regularly utilize the safety routing function are needed to showcase to city administrations that the application can increase perceived cycling safety and thus motivate other citizens to use the bicycle. This could create an incentive for city administrations to carry the costs of the application in the long run. To identify the abovementioned user groups and their expectations toward the RouteMeSafe application, two studies with frequent and infrequent cyclists were conducted. The two groups are known to have different risk perceptions during cycling according to Lehtonen et al. (2015). Consequently, it was hypothesized that they have different expectations toward the functions of a cycling security application. Study 1 was a user experience study aimed at determining for which functions of the RouteMeSafe application frequent and infrequent cyclists could serve as a target group and what they expect of them based on a student sample from Stuttgart. Study 2 was a technology acceptance study investigating the expectations of frequent cyclists regarding the feedback function based on a sample with citizens of Stuttgart in more detail. As a basis for study 1, the Hedonic-Pragmatic Model by Hassenzahl (2001) and the Kano Model by Kano (1984) were used, which will be introduced in the following.
2.2 Study 1: UX Study with Frequent and Infrequent Cyclists

2.2.1 Hedonic-Pragmatic Model

In the corporate environment, emotional (hedonic) as well as functional (pragmatic) product qualities are becoming increasingly important (Diefenbach & Hassenzahl, 2017). A basic model of hedonic and pragmatic product characteristics is the Hedonic-Pragmatic Model by Hassenzahl (2001). The *hedonic quality* of a product describes emotional aspects of the product experience (Hassenzahl, 2001). An example for that is the perception of the product by the customer as beautiful, interesting, or innovative. The *pragmatic quality* of a product describes its utility and usability for the customer (Hassenzahl, 2001). This includes, for example, the customer’s perception of the product as practical, simple, or clear. In the model, the *hedonic* as well as the *pragmatic quality* is related to the perceived attractiveness of the product, which in turn is related to the behavioral consequence (e.g., increased use) and the emotional consequence (e.g., joy) (Hassenzahl, 2001). Figure 2.2 illustrates the *Hedonic-Pragmatic Model* by Hassenzahl (2001).

2.2.2 Kano Model

In addition to determining expectations toward *hedonic* and *pragmatic qualities* of an application, it can be beneficial to find out which *additional functions* potential users expect. Covering expectations thoroughly is important in product development. According to Michalco et al. (2015), users approximate their product rating to the level of disconfirmation, when their expectations are not met and vice versa. The Kano Model by Kano (1984) provides a sound basis for evaluating expectations toward additional functions for the RouteMeSafe application.

The Kano Model describes the relationship between the fulfillment of expectations and customer satisfaction (Hölzing, 2008). In the model, the attributes (functions) of a product are divided into five categories that have different effects on customer satisfaction: basic attributes, performance attributes, attractive attributes, indifferent attributes, and reverse attributes (Engelhardt & Magerhans, 2019). Table 2.1 shows a description of the product attributes in the Kano Model.

In summary, it can be said that the *hedonic-pragmatic model* by Hassenzahl (2001) provides a basis for determining the holistic evaluation with regard to hedonic and pragmatic qualities of a product by potential users. The Kano Model by Kano (1984) provides a foundation for understanding whether *additional features* are desired by potential users. Based on these findings in literature, a study of the RouteMeSafe application was conducted at Stuttgart University of Applied Sciences.
2.2.3 Methodology

Students were recruited by e-mail and incentivized with course credits. The inclusion criteria were that the participants could operate a smartphone and ride a bicycle. In addition, it was attempted to generate a balanced sample of frequent and infrequent cyclists. Since the two groups have a different risk perception according to Lehtonen et al. (2015), different expectations toward the RouteMeSafe application were hypothesized. The experiment was divided into three parts: a preliminary survey, testing of the application while cycling over a predefined route in Stuttgart, and a follow-up survey. By testing the application in the field, it was intended to create an experimental context as close to reality as possible. In the preliminary survey, general data on the participants and cycling frequency, expectations toward the application, as well as the perceived cycling safety were collected. When testing the application, the participants were instructed to record at least two dangerous spots and to evaluate two existing dangerous spots (entered by other
A survey evaluating the application was conducted afterward. The follow-up survey again included the subjects’ perceived cycling safety. Furthermore, the user experience of the application was assessed by participants via the short version of the User Experience Questionnaire Short (UEQ-S), which is based on the Hedonic-Pragmatic Model by Hassenzahl (2001). The UEQ-S was chosen as a central instrument because the questionnaire allows to measure the user experience reliably and quantitatively with a small number of items (Sarodnick & Brau, 2011). In order to find out whether the target group would like to have additional functions for the application, the standard questionnaire of the Kano Model by Kano (1984) was used. The following ideas for additional functions were evaluated by the participants: a safety routing function (avoiding dangerous spots), a function that includes predefined routes (along popular landscapes and sights), a community function (platform to discuss cycling security), and a function that enables tracking of the cycled routes (environmental impact compared to other modes of transport). Furthermore, the participants were asked which additional functions they consider useful in addition to the ones evaluated in the Kano analysis.

2.2.4 Results

Thirty-one students with an average age of 26 years completed the experiment. Seventy-four percent of the sample were female and 26% male. Forty-eight percent of the participants stated that they used the bicycle at least once a month and were categorized as frequent cyclists, and 52% stated that they used the bicycle less than once a month and were categorized as infrequent cyclists.

The UEQ-S ratings of the application in terms of pragmatic, hedonic, and overall quality ranged between 0.4 and 0.8. According to Schrepp, Hinderks, and Thomaschewski (2017), this can be interpreted as neutral values. A comparison of the perception of safety before (mean = 2.5, on a scale from 1 (very unsafe) to 5 (very safe)) and after use of the application (mean = 3.5) showed a significant increase. The subjects reported a significantly higher perceived cycling safety (z = –2.496, p = 0.013) after using the application. In both, the evaluation of the RouteMeSafe application in the UEQ-S and the safety perception of cyclists before and after use of the application, no differences were found between frequent and infrequent cyclists. Accordingly, the application had a positive effect on the perceived safety of both groups. Table 2.2 shows the results of the UEQ-S.

The Kano analysis showed that a security routing function was categorized as a performance attribute (O) by the participants. Predefined routes and tracking statistics were categorized as attractive attributes (A). The community function was categorized as an indifferent attribute (I). The Fong test checks all four category assignments for significance and becomes significant if the inequality is not true. This was the case for all four

1A Mann–Whitney U-test has been conducted.
functions: Navigation (8<3.84), predefined routes (17<6.48), community function (13<6.48), tracking statistics (20<6.47). Table 2.3 shows the results of the Kano analysis.

The additional features most frequently suggested by the participants were an acoustic notification of nearby dangerous spots (81.50%), automatic map rotation in the direction of cycling (74.10%), and categorization of dangerous spots according to their severity (66.70%). However, infrequent cyclists did not expect any additional features in the application.

### 2.2.5 Discussion

The expectations of the participants regarding the application were partially fulfilled. The pre- and post-use analysis of the application shows that it increases perceived cycling safety in the short term. In future studies on the application, it should be examined whether this effect remains after a long-term use. The neutral values on the UEQ-S constructs indicate that the expectation of simplicity and reliability is only partially fulfilled in the current prototype. The implementation of a safety route, an acoustic notification of nearby dangerous spots, the automatic turning of the map in cycling direction, and a categorization of dangerous spots according to their severity could improve the simplicity and reliability of the application. This should be investigated further in a usability test after the implementation of these functions. Infrequent cyclists expressed that they expect a security routing function. After the function has been developed, user experience tests with this target group should be conducted in order to check whether they could serve as a target group for it. Frequent cyclists indicated that they did not expect any additional functions such as safety routing for the application. This indicates that frequent cyclists could be considered as a target group for the feedback function of the RouteMeSafe application. To test this hypothesis on a larger sample and further investigate the expectations of frequent cyclists.
regarding the *feedback function*, study 2 was conducted. The Unified Theory of Technology Acceptance 2 (UTAUT2) was used as a basis.

2.3 Study 2: Technology Acceptance Study with Frequent Cyclists

2.3.1 Unified Theory of Technology Acceptance 2 (UTAUT2)

UTAUT2 is a technology acceptance model designed for the consumer use context, which has been widely used in studies researching various technologies (Tamilmani, Rana and Dwivedi, 2017). The model proposes a direct influence of performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, habit, and price value on the intention to use a technology, which is the best predictor of the actual use of a technology. Furthermore, moderating effects of age, gender, and experience on the relationships of facilitating conditions, hedonic motivation, habit, and price value with the intention to use a technology are stated. Also, a moderating effect of experience on the relationship of the intention to use a technology with the actual use of a technology is proposed in the model (Venkatesh et al., 2012). Figure 2.3 illustrates the UTAUT2. This model was the basis of study 2.

2.3.2 Methodology

Participants were recruited via the newsletter of the General German Bicycle Club (ADFC). This medium was chosen because of the assumption that most of the members of the ADFC would be frequent cyclists. In the first part of the online survey, the functions of the *RouteMeSafe application* and its development status were described and illustrated with screenshots. Then the participants were asked to state their opinion on the prototype (*feedback function* only) and then on the overall concept of the application (feedback and security routing function) based on the UTAUT2 constructs. In this, the original items of Venkatesh et al. (2012) with the anchors 1 (strongly disagree) and 7 (strongly agree) were used. In the last part, questions about possible purposes of use, desired additional functions, demography, and frequency of cycling were asked.

2.3.3 Results

A total of 29 members of the General German Bicycle Club (ADFC) with an average age of 50 years were surveyed. Fourteen percent of the sample were female and 86% male. All participants stated that they used their bicycles at least once a month which confirmed the assumption that most of the ADFC members would be frequent cyclists and 86% of the sample even several times a week. The participants stated that they could imagine using the
prototype regularly (mean = 5.9). The subjects imagine the prototype to be useful (mean = 6.1), easy to use (mean = 5.6), and even entertaining (mean = 4.9). In addition, they indicate that their social environment would support that they use the prototype of the application (mean = 4.5) and that their smart phone would be suitable for using the prototype (mean = 6.4). The overall concept of the application (feedback and security routing function) portrayed a similar picture. The participants stated that they could imagine using the application regularly (mean = 5.7). Furthermore, they imagine the application to be useful (mean = 5.8), easy to use (mean = 5.4), and entertaining (mean = 5.0). They also indicate that their social environment would support it if they used the application (mean = 4.4) and that their smart phone would be suitable for using the application (mean = 6.4). Participation in cycling infrastructure measures (79%), cycling tours (79%), and the route to leisure activities (76%) were stated as the most likely purposes of use. The majority of the sample could imagine using the application on known as well as on unknown routes (76%). Other desired features were a categorization of dangerous spots according to their severity, a feedback function on measures taken to eliminate reported hazards, and black ice warnings.

Fig. 2.3 Illustration of UTAUT 2 according to Venkatesh et al. (2012)
2.3.4 Discussion

Frequent cyclists already state high acceptance of the prototype of the RouteMeSafe application. The group shows a high usage intention and imagines the application as useful, easy to use, and entertaining. One of the two most frequently mentioned purposes of use is the participation in cycling infrastructure measures. This indicates that frequent cyclists could be a target group for the feedback function. Another important motivator for the regular entering of dangerous spots with the application could be a notification function on the status of measures initiated to eliminate reported dangerous spots. After implementation of the function, this assumption should be tested in a further user experience study.

2.4 General Discussion

Two studies were conducted with the aim to determine the target groups for the functions of the RouteMeSafe application. The results of study 1 with 31 students indicated that infrequent cyclists could be a target group for the security routing function of the RouteMeSafe application and frequent cyclists could be a target group for the feedback function. The former should be checked in a further technology acceptance study based on a large sample with citizens of Stuttgart. The latter was confirmed in study 2 with 29 ADFC members. Frequent cyclists already indicate high acceptance of the prototype in its current development state. They could thus serve as the required users who fill the applications database. Functions such as a categorization of dangerous spots according to their severity, a feedback function on measures taken to eliminate reported hazards, and black ice warnings could further increase acceptance in this group. After these functions have been implemented, their user experience should be investigated based on a randomly selected sample with frequent cyclists from Stuttgart. Furthermore, diary studies investigating the user experience of the RouteMeSafe application should be conducted with infrequent and frequent cyclists from Stuttgart. Doing so could help to find out whether both groups can serve as target groups of the security routing and feedback function on the long run.

Acknowledgments The project i_city: Intelligent City is funded by the Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research) under the funding number 13FH9I011A and supervised by the project management agency VDI Technologiezentrum GmbH on behalf of the Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research).


Open Access This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter’s Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter’s Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.