All Eyes on You! Impact of Location, Camera Type, and Privacy-Security-Trade-off on the Acceptance of Surveillance Technologies

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Abstract. While surveillance technologies are increasingly used to prevent or detect crimes and to improve security, critics perceive recording and storage of data as a violation of individual privacy. Thus, it has to be analyzed empirically where and to what extent the use of surveillance technologies is accepted and whether the needs for privacy and security differ depending on the location of surveillance, the type of technology, or the individual characteristics of city residents. By applying a conjoint analysis, our study investigated the relationship between different locations of surveillance, different types of cameras, increase of safety implemented by reduction of crime and intrusion of privacy operationalized as different ways of handling the recorded footage. Findings show that locations are the most important factor for crime surveillance scenario preferences, followed by increase of security, and intrusion of privacy. In the decision scenarios, the type of camera played only a minor role. Sensitivity analyzes enabled detailed examinations of the trade-off between privacy and security and a segmentation of different respondent profiles led to an identification of influencing characteristics on the acceptance of crime surveillance. Outcomes show the importance of integrating city residents' preferences into the design of infrastructural city concepts.

Keywords: Surveillance technologies · Technology acceptance
Conjoint analysis · Privacy-Security-Trade-off

1 Introduction

In the last years, the use of crime surveillance technologies (CST) in private and public environments has increased significantly, mainly due to terrorist attacks and rising crime rates [1]. Considering urbanization processes and the demographic change, the majority of people will live in cities rather than other regions by 2030 [2]. Therefore, it will be of great importance to what extent city residents accept surveillance technologies, on the one hand, and what information about benefits and caveats needs to be provided so residents are adequately informed.

At the present time, several hundred million cameras are installed in public and private environments around the world [3, 4]. CST, e.g., cameras, microphones, detection and localization technologies, are used increasingly to enhance security.

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However, critics fear an invasion of privacy by recording and storage of data material [5]. Hence, research concerning CST acceptance is inevitable to determine at what locations and on what terms it is accepted and which circumstances may lead to changes in the need for privacy and security.

1.1 Usage of Surveillance Technologies in Urban Areas

Aiming at investigation or detection of crime and an increase of security, a rising number of CST is currently used in almost every city in the world [3, 6, 7]. This development is heavily critized, especially by data protection specialists who see the recording and storage of data as violation of a human's privacy and personal rights [8, 9]. In particular, the usage or processing purpose of recorded data material in urban areas is raising concerns: By whom, where, and for how long is the recorded data stored? Is the recorded data used for localization or recognition purposes, who has access to it, and who benefits from it?

Thus, the conflict between security and privacy is increasingly gaining importance that leads to central questions regarding the implementation of CST in urban areas: At which locations and on what terms is privacy or security more important? Are people willing to sacrifice their privacy to gain perceived safety? More and more CST are used without considering the requirements and needs of city residents or involving them into decision-making processes on the installation of CST in cities [10, 11]. In order to reach an accepted and positively perceived urban design, it is necessary to include residents into the implementation process and take their wishes, fears, and needs into account. Only this way, a long-term acceptance and adoption of CST in urban environments can be achieved.

Previous studies primarily focus on innovative technical and functional features of CST such as camera, microphone, localization, and detection technologies [12, 13]. In part, some politically or police motivated studies examine the effectiveness of CST, usually in terms of a decrease in crime rates at monitored locations or increased rates of revealed offenses [14, 15]. Furthermore, the regulation of the use and proliferation of surveillance technologies and associated legal, juristic and ethical aspects are discussed [16]. However, only little knowledge exists about the acceptance of CST at private and public locations because CST are usually integrated into urban environments without considering opinions and needs of urban residents. CST acceptance is, if at all, only superficially addressed: Attempts were made to understand acceptance of CST by means of theoretical models (e.g., [17]), in which city residents are not directly integrated though. In most of the previous studies of CST, it was determined whether crime surveillance is generally accepted or rejected (e.g., [18]), without detailing the underlying reasons. Thus, no consideration of potential impact factors has been conducted, e.g., different types of CST or locations of crime surveillance. Therefore, an empirical study is necessary that investigates the acceptance of CST as a function of several impact factors such as locations, type of technology, and different needs for privacy and security.

1.2 Acceptance of Surveillance Technologies

Perceived safety and protection of one's own privacy are important determinants of CST acceptance [9]. Understanding factors that influence technology acceptance is essential for a successful adoption and integration of innovative technologies [19].

The Technology Acceptance Model (TAM) is a well-established theoretical approach to explain and predict the adoption of technologies [20]. It provides a basis for many other acceptance models and has been adapted for a variety of contexts (e.g., [21]). However, for the purpose of CST acceptance, there is no established acceptance model yet. Previous acceptance models might not be transferrable to the context of CST for several reasons. Most acceptance models are limited to two key factors: ease of use and perceived usefulness of a technology or application [20]. Thus, other acceptance determinants are disregarded. The TAM was originally developed for end-user computing, directed on ICT usage in a job-related context. Since CST are implemented in a completely different and much more complex usage context, we assume that relevant factors of CST acceptance are not yet adequately considered. Previous research shows that even the same technology applied to different usage contexts evokes different acceptance patterns and underlying motives and barriers [22]. Further, technology acceptance models focus on an evaluation of *complete* technical systems. As a result, only general benefits and barriers of a technology or the generic intention to use can be assessed while insights into the importance of single technical characteristics and practical design guidelines are not possible. More specifically, nothing can be said about which type of surveillance technology is most accepted at which location and, depending on this, where needs for either privacy or safety predominate.

Even though the TAM successors (e.g., [21] integrated individual factors into the acceptance model, the effect of these factors, such as attitudinal variables beyond demographic characteristics (age, gender), has not been investigated yet. Moreover, existing models do not allow to derive user profiles, which allow for a more target-group-specific formulation of design guidelines in city planning processes. Finally, coming to methodological issues, questionnaires designed on the basis of TAM, do not allow to holistically portray complex decision scenarios, in which several decision criteria are weighted against each other. More specifically, it is not possible to draw conclusions about relative importance, relationships, and interactions of factors concerning CST acceptance, e.g., locations of CST implementation, type of technology as well as needs for safety and privacy. By combining a conjoint analysis with a traditional questionnaire, more information can be obtained and different attributes of CST acceptance as well as their interrelations can be analyzed in detail.

1.3 Research Questions and Aim of the Study

So far, the acceptance of CST has been investigated by considering potential influencing factors separately. Thus, it was the aim of the present study to explore factors that have been proven to be relevant for the acceptance of CST by a direct weighting of these factors against each other. In doing so, the following research questions were investigated:

- Does the location, the applied technology, safety, or privacy influence the decisions in crime surveillance scenarios the most? (RQ1)
- At which turning points tendencies of acceptance do convert in rejection? (RQ2)
- How is the trade-off between safety and privacy evaluated in detail? (RQ3)
- Which user profiles can be derived that evaluate the crime surveillance scenarios differently? (RQ4).

The paper is an extension to previous work [23], in which general findings have been reported differing between diverse surveillance contexts. Here, the specific context of crime surveillance is focused in detail, as crime surveillance is an essential part of public life in smart cities.

2 Methodology

Based on the findings of a preceding study in which CST acceptance was examined by means of focus groups and questionnaires, it was revealed that CST acceptance is influenced by several key characteristics and attributes that do play important roles for residents [24]. The present study is a follow up of this previous work, using a conjoint measurement approach. The aim of this study was to assess preferences for video-based crime surveillance scenarios, considering different locations of surveillance, different camera types, security as benefit in terms of a reduction in crime rate, and privacy as barrier, operationalized with different ways of handling recorded data.

2.1 Conjoint Analysis

Conjoint analyses combine a measurement model with a statistical estimation algorithm and were developed by Luce and Tukey [25]. In contrast to conventional survey-based acceptance research, conjoint analyses enable a holistic and more valid examination of decision scenarios, an exposure of single attributes against each other, and direct simulations of relationships and interactions. Within a conjoint analysis, specific product configurations but also different scenarios are assessed by the respondents. These products or scenarios consist of multiple attributes and differ from each other in the attribute levels. Conjoint analyses allow simulations of decision processes and fragmentations of product or scenario preferences into separate part-worth utilities of the attributes and their levels [26]. As a result, the relative importance of attributes deliver information about which attribute influences the respondents' choice the most. Part-worth utilities label which attribute level is valued the highest. Preference ratings and resulting preference shares can be interpreted as indicator of acceptance. A choice-based-conjoint analysis approach (CBC) was chosen, because it imitates complex decision processes, in which more than one attribute influences the final decision [27].

2.2 Selection of Attributes

One of the first and most important steps in the conceptualization stage of conjoint analyses is the identification and selection of relevant attributes and the number of levels, because this affects the significance and generalizability of findings [28]. The designer of a conjoint study must ensure that all relevant attributes that determine respondents' preference, on the one hand, and are relevant for policy-makers or city-planers, on the other hand, are considered. Beyond an extensive literature analysis, we used the outcomes of the prestudy [24], in which relevant criteria for the acceptance of CST were identified and selected for the subsequent conjoint study. The following attributes were evaluated in the conjoint study: locations, camera types, crime reduction (indicating safety), and handling the recorded footage (indicating privacy). In the next sections, it is explained how and why these attributes have been selected.

Location of CST Implementation. Acceptance of CST is higher for public than for private locations [24, 29–31]. However, the question arises how CST are perceived at semi-public locations, especially in direct decision situations. The findings of our pre-study showed that perceived crime threat and CST acceptance varied among different public and semi-public places. Therefore, not only the contrast between private and public locations but also two semi-public locations were chosen as attribute levels. Based on the ratings of perceived crime threat at different locations [24], a representative prototype was selected:

- own house (private)
- store (semi-private)
- market (semi-public)
- train station (public).

Type of Surveillance Technologies. Concerning different types of surveillance technologies, we focused on video-based surveillance because it is the most established and used type of surveillance technology (e.g., [9]). It was also favored in the prestudy in contrast to other technologies, e.g., microphones. To examine attitudes towards video-based technologies in detail, we distinguished between four types of cameras differing primarily in their size and visibility:

- big, tracking camera (large & visible)
- dome camera (smaller & less visible)
- mini-dome camera (small & partly hidden)
- integrated camera (very small & hidden).

This distinction among the dimensions "size" and "visibility" was made because large and visible cameras are mainly used for surveillance in public space, but seamless camera integration (e.g., in objects or clothing) is gaining popularity across different application areas [32].

Security. The most important benefit of CST is an increase in security, because crimes are detected or can be prevented through deterrence [1]. In our prestudy, crime reduction was also perceived as one major benefit of CST. Therefore, the attribute *crime reduction* was chosen as third attribute for the conjoint analysis. The definition of crime reduction levels was based on findings regarding the effectiveness of video-based crime surveillance (e.g., [33]):

- 0%
- 5%
- 10%
- 20%

Privacy. Privacy concerns are an important public concern in the context of CST implementation [8]. More specifically, violation of privacy due to storage of data material and unwanted release of personal information is perceived as critical [5, 9]. In our prestudy, storage and re-use of personal data was evaluated as barrier of CST acceptance. Thus, the category handling of recorded footage was selected as fourth conjoint attribute. To further investigate the evaluation of different categories of "privacy intrusion", the following four levels were chosen:

- archiving of data by police
- storage in profile databases
- face recognition
- location determination.

2.3 Experimental Design

Based on these considerations, four attributes and relevant levels were chosen for the CBC studies. No prohibitions for level combinations were included because all chosen attribute levels were combinable. In every CBC task, four sets of scenario configurations were presented without the opportunity to choose a "none-option". In order to improve comprehensibility, the attribute levels were presented partly in visual and partly in written form (Fig. 1). Overall, participants had to evaluate ten choice tasks, each consisting of four different combinations of the attributes *locations, crime reduction, handling of recorded footage,* and *camera types*.

Because a combination of all corresponding levels would have led to 256 ($4 \times 4 \times 4 \times 4$) possible combinations, the number of tasks was reduced [27] and, overall, 10 random and one fixed task were presented to the respondents. A test of design efficiency was used to consider whether the design is comparable to the hypothetical orthogonal design [34]. The result confirmed that the design was sufficient regarding a total of at least 100 respondents.

2.4 Questionnaire

The questionnaire of the online survey was created using the SSI Web Software. Participants started the survey by opening a link which was sent via e-mail or advertised on public internet sites. Prior to the choice tasks, demographic data and information on type of residence and residential location were collected. This was followed by querying perceived needs for security and privacy. To gather data concerning security and privacy needs, for each four statements had to be evaluated on a six-point

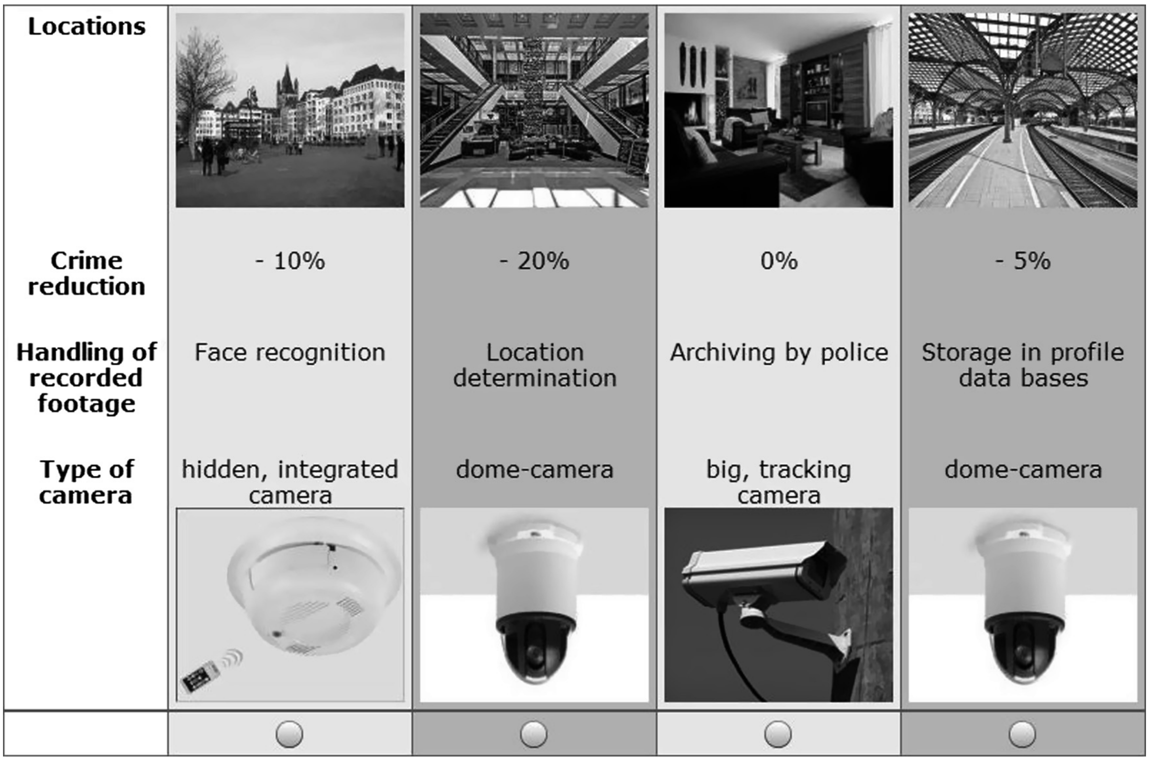

Fig. 1. Example of scenario decision with four attributes and their attribute levels [23].

Likert scale (1 = strongly disagree; 6 = strongly agree). In addition, perceived crime threat (PCT) was evaluated using a six-point Likert scale (1 = very low; 6 = very strong) adapted from a preceding study [31]. Based on ratings for different security needs, privacy needs and PCT, sum scores were calculated. Concluding this questionnaire, the participants were asked for previous experiences with crime. It was distinguished between slight crime (e.g., bicycle theft) and serious crime (e.g., robbery). This was followed by the introduction of attributes and their characteristics, including their visual representation. Afterwards, the respondents were prompted to select the preferred scenario in every scenario decision of the conjoint tasks. As a control, they were to imagine that they are alone at the respective locations during the day. Finally, the respondents were instructed to select a scenario in each choice task, that met their individual needs for security and privacy most closely.

2.5 Data Analysis

Data analysis (i.e., estimation of part-worth utilities, preference simulations) was conducted using Sawtooth Software: SSI Web and SMRT. In a first step, part-worth utilities were computed on the basis of hierarchical bayes estimation and part-worth utili-ties scores were deduced [27]. Relative importance of attributes deliver the information how important an attribute is relative to all other attributes for the scenario selection. The relative importance of an attribute was calculated by taking range of part-worth utility values for each factor and dividing it by the sum of the utility ranges for all factors. However, part-worth utility scores are interval-scaled within each attribute and, thus, a comparison of utility scores between different attributes is not possible [26]. In contrast, it is possible to compare differences between attribute levels, if using zero-centered differentials part-worth utilities, because they are summed up to zero within each attribute. In a second step, preference simulations estimate the influence on preferences if certain attribute levels change or are consciously kept constant within a specific scenario [26]. The simulation of preferences enables specific "what-if"-examinations, e.g., the influence of the privacy-security-trade-off on respondents' preferences can be analyzed in detail within a predefined scenario. Finally, Latent Class Analysis (LCA) is used to analyze the impact of different respondent profiles on the acceptance of crime surveillance.

2.6 Sample

In total, 193 people participated in the online survey. Sixty-three questionnaires were filled out incompletely and were therefore excluded from the analysis (n = 130). This corresponds to a return rate of 67.4%. The mean age of the participants was 32.0 years (SD = 12.2) with 60% females and 40% males. Regarding the type of their residence, 60% of the respondents live in an apartment building, 20% in a detached house, 13.1% live in a row house and 6.9% in a semi-detached house. Asked for their residential area, the majority of respondents revealed to live in the city center (43.1%), while 22.3% live on the outskirts, 20% in suburbs, and 14.6% live in a village. As described above, different needs for privacy and security as well as PCT were calculated as sum scores (min = 4; max = 24). Overall, an average need for security (M = 12.4, SD = 4.7) and an average perceived crime threat (M = 10.0, SD = 3.7) were existent. Needs for privacy were generally very high (M = 22.2 (out of 24 points max), SD = 2.3).

3 Results

First, the relative importance of attributes are presented, followed by part-worth-utility estimation results for all attribute levels. Afterwards, the results of different preference simulations and segmentation analyzes are described.

3.1 Relative Importance Scores (RQ1)

Hierarchical Bayes analysis was used to determine the importance scores of attributes and, thus, to discover main factors influencing the acceptance of crime surveillance.

As can be seen in Fig. 2, locations had the highest importance score in the scenario selection (42.4%) and, therefore, it is the most important determinant concerning crime surveillance acceptance. Crime reduction (23.1%) and handling of recorded footage (20.0%) gained similar importance, while crime reduction has a slightly more important meaning for the scenario decisions. Types of camera (14.6%) had the lowest influence on the scenario selection and, thus, it presents the attribute with the lowest impact on the acceptance of crime surveillance.

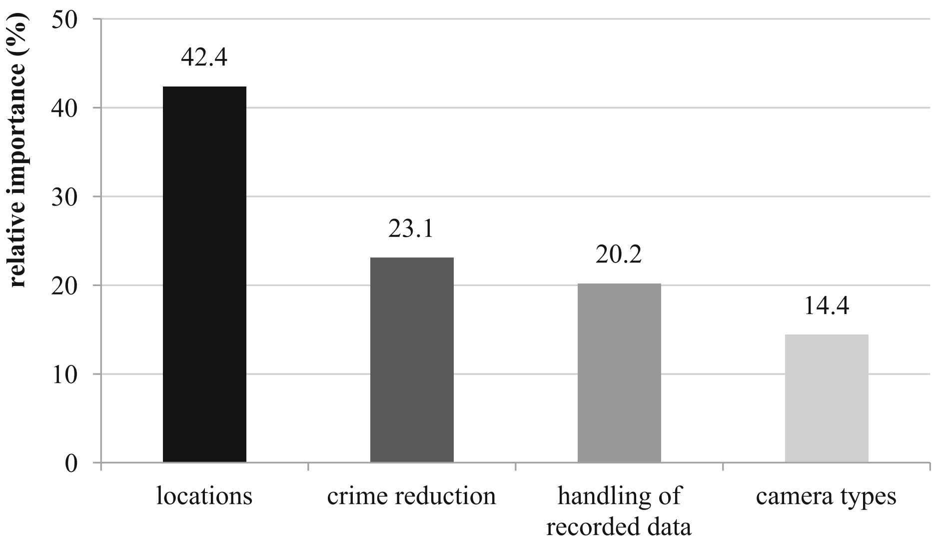

Fig. 2. Relative importance scores of attributes.

3.2 Part-Worth-Utility Estimation (RQ2)

Following, the part-worth utilities are presented for all attribute levels (Fig. 3). This way, the attribute levels with the highest utility values were identified in order to provide recommendations to city planners of future urban quarters about which scenario would, hypothetically, reach the highest acceptance in the context of crime surveillance. The best rated scenario was surveillance at a "train station", with a "crime reduction of 20%", "archiving" of data material, and using the "large, tracking camera".

Regarding absolute utility values, the attribute levels of *locations* reached the highest and lowest utility values, explained by the high relative importance score of this attribute. "Train station" received the highest utility value (44.0) and was consequently most accept-ed. "Market place" (20.9) and "department store" (10.6) reached lower scores, while the "own home" was strongly rejected with the lowest utility score (−75.5).

The second largest span and an almost linear behavior of the utility function belonged to the attribute *crime reduction*: Here, the "crime reduction of 20%" (33.7) received the highest value and was most accepted, while "crime reduction of 0%" (−41.2) reached the lowest utility value and was rejected. "Crime reduction of 10%" (14.9) was rated higher than a "crime reduction of 5%" (−7.4).

Within the attribute *handling of recorded footage,* "archiving by police" (21.7) obtained the highest utility value while "face recognition" (−19.2) clearly received the lowest utility value. "Location determination" (1.9) was evaluated slightly higher than "storage in a profile database" (−4.4).

The utility function of the attribute *camera types* shows a nearly linear relationship. The highest value achieved the "large moving camera" (15.2), while the "integrated camera" (−14.6) got the lowest score. The "dome camera" (3.9) reached a slightly higher utility value than the "mini-dome camera" (−4.5).

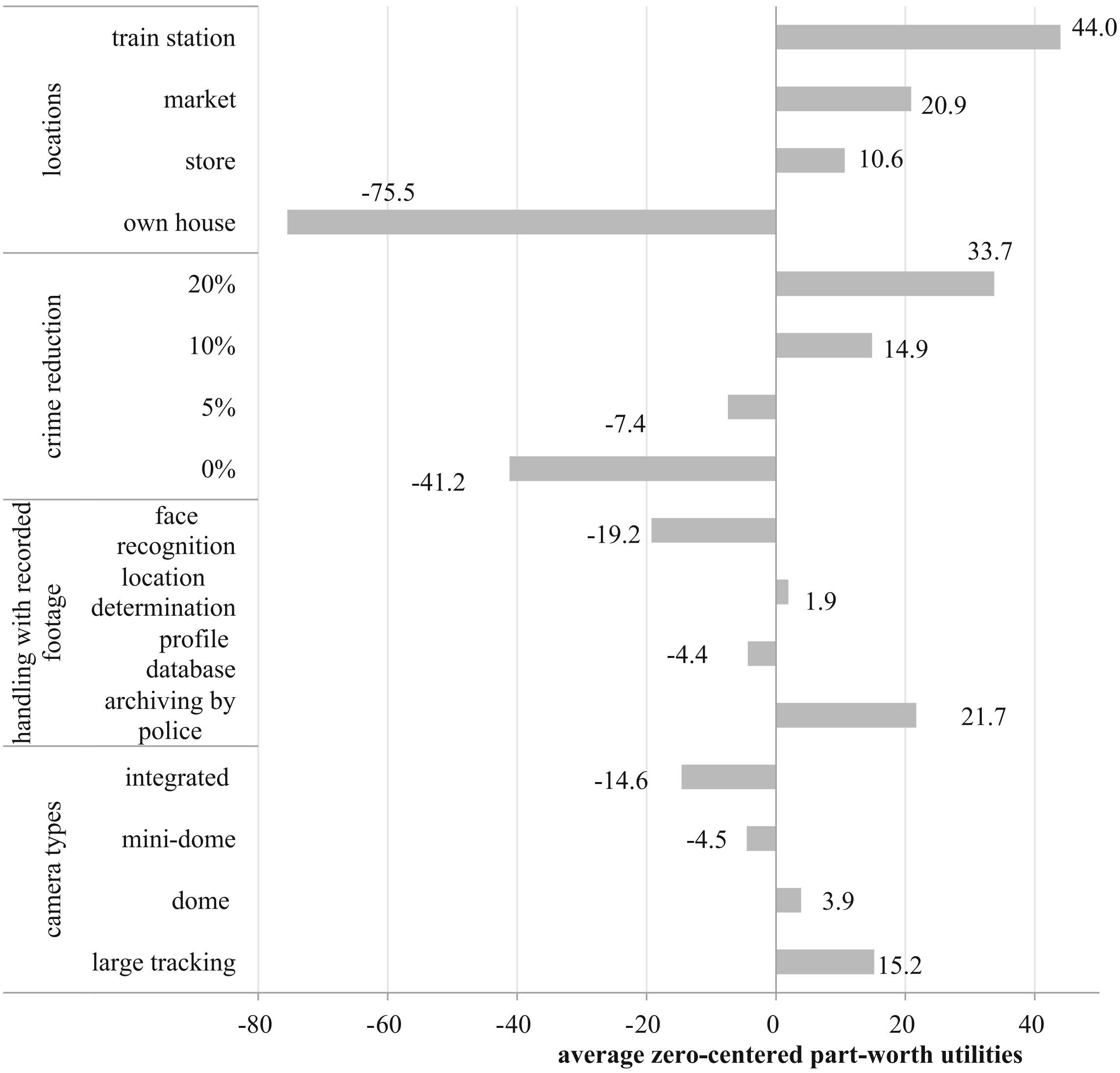

Fig. 3. Average zero-centered part-worth utilities.

3.3 Trade-off Between Security and Privacy (RQ3)

Using the market simulator of SSI web software, the trade-off between security and privacy was analyzed in so-called sensitivity analyzes. For that, the calculated values of the Hierarchical Bayes estimation were imported into the SMRT software. Preference simulations examine the extent to which relative preferences of a respondent vary, if single levels of an attribute change while other levels of attributes are kept constant [35].

As the relative importance of the attributes "crime reduction" (indicating security) and "handling of recorded footage" (indicating privacy) was very similar, the sensitivity analysis was regarded for constant privacy and security attributes to analyze the trade-off in detail. Based on the findings in previously reported part-worth utility analyses, three scenarios of attribute levels settings were constructed:

1. *high security* and *low privacy* with the levels "crime reduction of 20%" and "face recognition";

2. *high privacy* and *low security* with the levels "archiving by police" and "crime reduction of 0%".
3. *average security and privacy* with the levels "crime reduction of 10%" and "storage in a profile database".

These levels were kept constant in the preference simulation while all the other levels of attributes changed (locations and camera types). Outcomes are pictured in Fig. 4.

A clear preference for the scenario *high security* was found, especially in public places. This scenario received ratings three to four times higher than the other scenarios (e.g., "train station": *high security*: 66.5%, *high privacy*: 20.0%, *average*: 27.1%). Interestingly, the security scenario was rejected for private environments, since the attribute level "own home" was rated very low in general (min = 9.0%; max = 15.3%). The scenario *high privacy* received the lowest ratings - in private as well as in public spaces and for all camera types. The *average* scenario is rated a little bit higher than the *high privacy* scenario, except for the private environment (own home), which was the least preferable scenario. Concerning the camera type, the ratings were not widely dispersed inside the scenarios. In all scenarios, the maximal rating belonged to the large tracking camera with a decreasing tendency towards the hidden, integrated camera. Here, high ratings regarding the *high security* scenario were also striking (e.g., "large tracking camera": *high security*: 66.5%; *high privacy*: 14.8%; *average*: 24.9%).

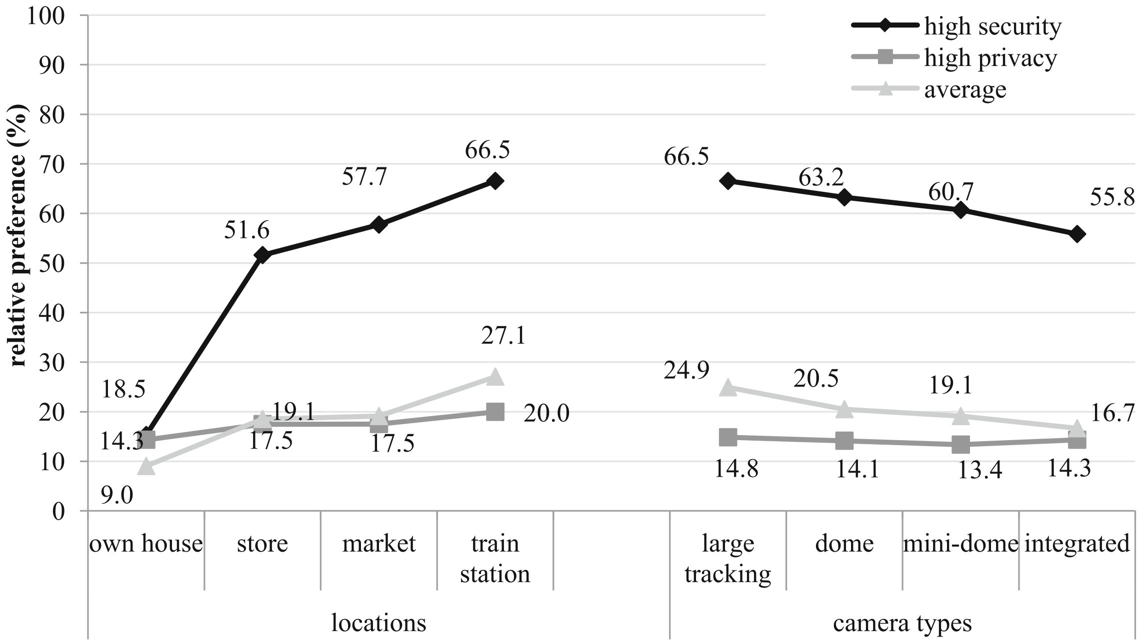

Fig. 4. Results of sensitivity analysis concerning the trade-off between security and privacy.

3.4 User Profiles (RQ4)

So far, the acceptance of crime surveillance technologies was reported for the whole group of respondents. However, residents in urban environments are highly heterogeneous, which suggests the existence of group-specific acceptance patterns. In order to detect groups of respondents with similar preferences based on their choices in the CBC questionnaires, latent class segmentation analysis (LCA) was applied [36]. A three-group solution (Table 1) showed a sufficient data fit according to the criteria percentage certainty, consistent Akaike information criterion (CAIC), and relative Chi square.

- ***Group 1,*** in the following simplified designated as the “worried” (N = 22), mainly consisted of people with a stronger need for security and a higher PCT.
- ***Group 2*** (N = 68), simplified designated as the “unworried”, represented participants with a rather low security need and PCT.
- ***Group 3*** (N = 40), simplified designated as the “undecided”, showed a balanced relationship concerning security need as well as PCT.

Further group differences in demographic characteristics missed statistical significance in ANOVAs. Group comparisons revealed different importance patterns (see Fig. 5).

Table 1. Group segmentation (based on LCA results)

	Group 1 (n = 22; “worried”)	Group 2 (n = 68; “unworried”)	Group 3 (n = 40; “undecided”)	P
Age (M; SD)	31.2(13.0)	33.1(13.0)	30.7(10.2)	n.s.
Gender (female, male in %)	68.2%, 31.8%	58.8%, 41.2%	57.5%, 42.5%	n.s.
Security need (M; SD)	14.5 (3.3)	11.5 (5.0)	12.8 (4.4)	<.05
Privacy need (M; SD)	21.8 (2.3)	22.3 (2.4)	21.9 (2.4)	n.s.
Crime threat (M; SD)	11.6 (2.9)	9.2 (3.9)	10.7 (3.4)	<.05

For the “worried” group, the attribute locations (55.6%) clearly was the most important determinant influencing crime surveillance acceptance, while all other attributes were of less but almost equal importance. Interestingly, the attribute locations was also the most important attribute for the “unworried” group (50.3%), while handling of recorded footage (23.2%) was second most important, followed by camera type and crime reduction with least importance. Another pattern emerged for the “undecided” group: security in terms of crime reduction (50.7%) was the most important determinant and locations (37.4%) were also of major importance. For this group, camera type and especially handling of recorded footage (privacy) were not important at all.

According to an extremely different relative importance of all attributes depending on the three groups, the part-worth utilities for all attribute levels were also extremely diverse (see Fig. 6).

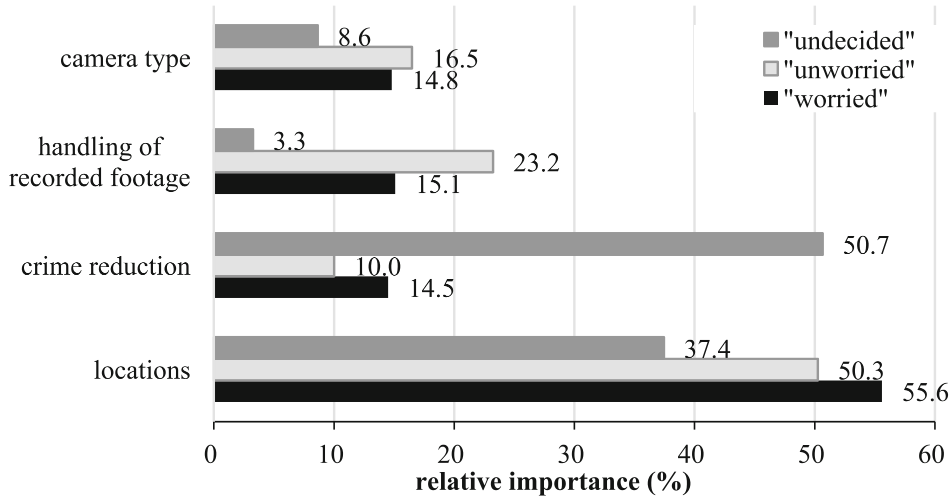

Fig. 5. Relative importance scores for segmented groups.

Concerning *locations*, very contrasting patterns were found. While the “unworried” and “undecided” groups preferred public locations for surveillance (e.g., train station: 78.8; 57.3), this was rejected by the “worried” group (−72.1) that preferred and accepted surveillance only at home (150.3).

The patterns of the attribute *crime reduction* were more similar. In all groups, a crime reduction of 20% was rated best and acceptance rose with increasing crime reduction. Crime reduction of 5% was an exception, because it was rated lowest by the “worried” group (−32.8). According to the high relative importance of the attribute, there were the lowest (crime reduction 0%: −112.1; crime reduction 20%: 90.6) and highest ratings in the “undecided” group.

Privacy in terms of handling of recorded footage was evaluated more differently. For the “undecided” group it was completely unimportant. The “unworried” group, preferred archiving of recorded data by the police (55.7) and strongly rejected the possibility of face recognition (−37.3). In contrast, the “worried” group preferred location determination (42.9) and rejected all other options of handling of recorded footage.

The attribute camera type also showed contrasting patterns. The “worried” group only accepted the integrated, hidden camera (41.4) and rejected all other types. However, the large tracking camera was preferred by the “unworried” (36.7) and the “undecided” (13.0) groups, while all other camera types were rejected or merely tolerated

4 Discussion

The present study evaluated preferences for different video-based crime surveillance scenarios, consisting of the attributes locations of surveillance, security (crime reduction), privacy (handling of recorded video material), and type of camera in a conjoint analysis.

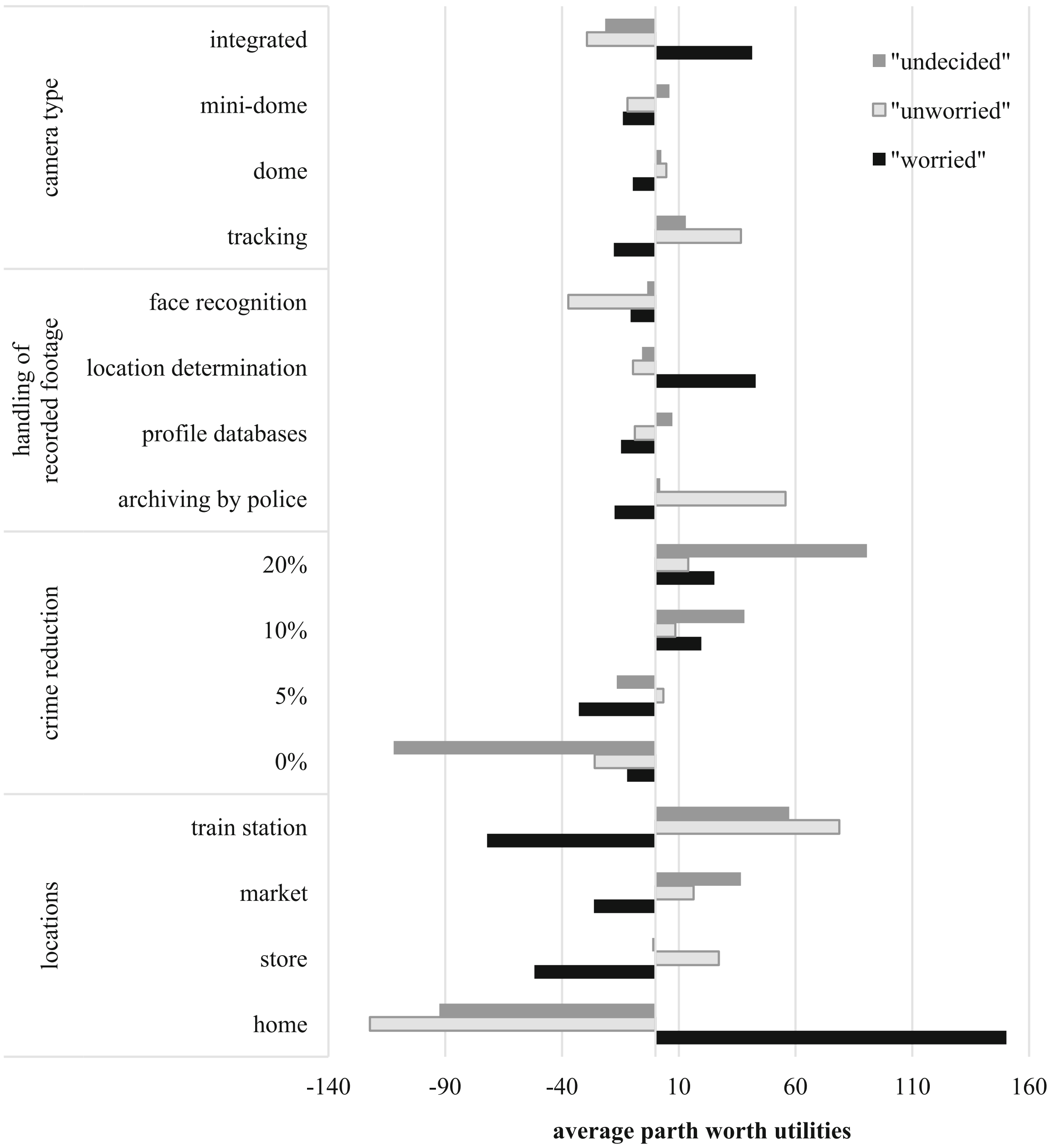

Fig. 6. Part-worth utilities (zero-centered diffs) for all attributes and levels for the groups "undecided", "unworried", "worried".

4.1 Acceptance of Surveillance Technologies in Urban Areas

Confirming previous research results (e.g., [18, 37]), the use of surveillance technologies is generally accepted in public locations in urban areas. Going beyond public spaces, our findings demonstrate that crime surveillance is not accepted at all in private spaces such as the own home. Interestingly, for medical surveillance applications, similar results were found for public and private locations [38]. In this study, the location of surveillance technology implementation was the most important factor in respondents' decisions for or against video-based crime surveillance scenarios. However, the importance of locations for surveillance acceptance is highly contextsensitive. For example, an equivalent conjoint study on medical surveillance showed a higher importance of security and privacy issues compared to locations [39].

In contrast to previous studies, which proved security and protection of privacy as important factors for acceptance without weighting them in direct decision situations [9, 37, 40–42], this study revealed that acceptance depends on perceived benefits in terms of increasing security and to a lesser extent on privacy-related issues. Technology-related aspects (such as the type of camera) played only a minor role for the acceptance of surveillance technologies.

However, the acceptance of surveillance technologies is no homogenous phenomenon but strongly shaped by individual factors of residents.

4.2 Specific Impacts on the Acceptance of Crime Surveillance

In this study, surveillance was not accepted at all in private spaces, but its acceptance rose with increasing publicity of locations. Thus, in public places, video-based surveillance systems are comparably well-accepted even in case of a rather low increase in security, i.e., low crime reduction.

Increase of security was another important factor in respondents' decisions, that increased linearly with the amount of crime reduction. Declines in the crime rate of "0%" and "5%" were perceived as insufficient, while a decline of "10%" was desired and preferences even redoubled for a crime reduction of "20%". Thus, the effectiveness of crime surveillance in terms of crime reduction is crucial for acceptance of crime surveillance.

In terms of privacy, archiving of data by police was most accepted, followed by location determination and storage in profile databases; face recognition was rejected. This result is especially important because face recognition technologies are increasingly used in public areas to fight and detect crime such as terrorist attacks [43].

Concerning camera types, acceptance decreases with increasing invisibility of cameras. The most visible large tracking camera is most accepted, while the hidden, integrated cam-era was rejected. This is especially surprising, because current technological developments – especially in the field of ambient assisted living environments – aim for designing smaller, less visible and seamlessly integrated technologies, e.g., in street or traffic lights, smoke detectors, smart homes [32, 44].

4.3 Trade-off Between Security and Privacy

Previous research on the trade-off between security and privacy emphasized that the will-ingness to trade one's own freedom, (mostly associated with privacy) for increased secu-rity depends on the level of increased security [43]. This study revealed that only a tangible crime reduction (at least 10%) is positively perceived as increase in security. Although, the analysis of relative importance initially revealed only a slightly higher importance of crime reduction (23.1%) in contrast to the handling of recorded footage (20.2%), for the scenario selection, secure scenarios were clearly preferred compared to scenarios that focused on privacy. Sensitivity analyses showed that security is much more preferred in a direct confrontation of security and privacy. Thus, security issues are more important criteria for the acceptance of crime surveillance than privacy issues, provided the technology is efficient, causes a noticeable decrease in crime rate, and consequently a gain in security.

4.4 Impact of User Profiles

In our study, we identified groups of participants with differing preferences in scenario decisions and differing needs for security and crime threat perception. Consistent with one of our preceding studies [30, 45], we found that especially different levels of perceived crime threat (PCT) affect evaluations of surveillance technologies. This finding is in line with recent studies, in which fear of crime influences the evaluation of the built environment [46]. Most noteworthy, people with a high PCT (the "worried" group, also characterized by a high security need) accept surveillance technologies at private locations while all other locations are rejected. In contrast, "unworried" or "undecided" respondents with a low or average PCT clearly prefer public locations for surveillance technology implementation and include security- and privacy considerations into their preference decision. The heterogeneity of preference patterns indicates that residents and their individual characteristics have to be known and considered in the design and integration of surveillance technologies in urban as well as private environments.

4.5 Limitations and Further Research

The applied conjoint analysis approach was useful for assessing preferences of different surveillance technology scenarios. However, it has some limitations to be considered in future studies.

First, estimated preference ratings do not mirror actual behavior, i.e., confirmation or rejection might be lower or higher in real situations (e.g., [47, 48]). A second limitation belongs to the limited number of attributes. A compromise had to be made between an economic research design with a limited number of attributes and the complexity of the research issue under study. Therefore, future studies will include further aspects, e.g., length of data storage, or use adaptive conjoint approaches (e.g., ACBC) allowing for bigger attribute numbers.

Further, some aspects have to be criticized in terms of content. The very similar evaluation of needs for privacy showed that the item content might have been too alike. In further studies, we will use more specific and tangible items concerning needs for privacy, which might lead to a more precise differentiation of respondents with different privacy needs.

Also, the study should be replicated in larger and more representative samples regarding, e.g., age, gender, and place of residence. Further, we assume that the evaluation of crime surveillance technologies is affected by current events such as terrorist attacks and offenses in the local environment. Thus, periodically longitudinal studies represent an interesting and necessary approach for further research. Certainly, the outcomes reflect a European perspective, only mirroring one cultural context which cannot be easily transferred to other countries in which the extent of crime might be completely different. Presumably, especially the trade-off between privacy and security might be different in societies with higher crime rates and a higher vulnerability of residents towards public assaults. Thus, we aim for a replication in other countries to compare crime surveillance needs and desires of city residents depending on their origins and cultures.

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