Where, Wherefore, and How?
Contrasting Two Surveillance Contexts According to Acceptance

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Keywords: Surveillance Technologies, Medical Vs, Crime Surveillance, Technology Acceptance, User Diversity, Conjoint Analysis.

Abstract: Surveillance technologies are used all over the world for various reasons. In urban environments, surveillance technologies are predominantly used for detecting or preventing crimes. Simultaneously, an increasing number of technologies are used for medical monitoring at home, but also at clinical facilities, and at public environments for assuring patients' medical safety. An intensive policy discussion about perceived advantages (especially increasing safety) and perceived barriers (in particular the invasion of privacy) comes along with the use of surveillance technologies. In this paper, it is examined where and for which contexts the use of surveillance technologies is accepted and under which conditions safety or privacy is perceived as more important. We investigate the acceptance of surveillance technologies for medical and crime surveillance scenarios using a conjoint analysis approach including four relevant aspects: location of surveillance, increase in safety, invasion of privacy, and the applied camera type. Results show both, context independent findings as well as context-sensitive findings: e.g., for crime surveillance, the location is most important followed by the trade-off between privacy and safety, while these three factors are of similar importance for medical surveillance. From a practical viewpoint, the findings might contribute to a differentiated surveillance policy in cities.

1 INTRODUCTION

Nowadays, modern societies face major challenges in order to cope with on-going urbanization demands: especially the demographic change, which require novel care and adequate supply concepts as well as enabling of living in smart, safe, and sustainable cities. Along with this comes the increasing development that higher proportions of people will live in cities than in all other regions. These substantial urbanization processes lead to consecutive challenges, which are difficult to balance. Apart from healthcare, economy, mobility, or governance issues, the implementation of safe and also well-accepted technical infrastructures and smart city concepts is focused worldwide (Ziefle et al., 2014).

Most large cities around the world use surveillance technologies (primarily video surveillance via cameras) in order to prevent and detect crime for increasing safety in cities and particularly at public locations (Dailey, 2013; Barrett, 2013). Progressively, surveillance technologies in smart city concepts (Filipponi et al., 2010; Dey et al., 2012) are increasingly connected, integrated, and implemented. This is especially driven by the motive to increase perceived safety for city residents as this is the essential condition for the participation in social and economic life and thus, it is a valuable asset for cities.

In spite of this undisputed positive aspect of surveillance, the violation of public's or city resident's privacy through recording, storage, and processing of (video) data represents the most discussed drawback and barrier of using surveillance technologies (Patton, 2000). The balance between both poles – privacy as a value and safety as a value – is quite intricate. A wide spectrum of resident's needs, especially their attitudes towards and requirements for safety and privacy have to be considered during the development and implementation of smart city concepts.

This trade-off is not only discussed for the crime surveillance context, but also matters in the context of medical surveillance. While surveillance technologies were mainly used for crime detection reasons in recent decades, they have been increasingly used for medical surveillance since the last years. Surveillance technologies - in particular AAL systems

Heek, J., Arning, K. and Ziefle, M.
Where, Wherefore, and How? - Contrasting Two Surveillance Contexts According to Acceptance.
DOI: 10.5220/0006362400870098
In *Proceedings of the 6th International Conference on Smart Cities and Green ICT Systems (SMARTGREENS 2017)*, pages 87-98
ISBN: 978-989-758-241-7

(Ambient Assisted Living) - become more and more popular in the context of chronic illness and medical monitoring (Leonhardt, 2006; Klack et al., 2011). In the medical context, one of the major goals of surveillance or monitoring systems is the detection of emergencies - especially falls - as falls are one of the most serious health risks for seniors (Rubenstein, 2006). Thus, medical surveillance technologies do increase not only perceived but also factual safety as a fast detection of emergencies and falls and consecutively immediate help reduce the risk of death by more than 80% (Gurley et al., 1996). Opposing this benefit of medical surveillance, there are concerns about an invasion of the own privacy in terms of a protection of personal information, e.g., anonymity, self-determination, personal control of data (Patton, 2000; Wilkowska & Ziefle, 2012). Thus, surveillance generally represents a conflict between two key motives: on the one hand, the wish to be safe as well as increase safety in urban environments and, on the other hand, the wish to stay private and to protect the own privacy. This conflict is difficult and almost impossible to address for city planners without understanding the residents' individual acceptance of surveillance technologies.

In this paper, the acceptance of surveillance technologies is empirically investigated differentiating between two urban contexts. Using a conjoint analysis, the critical trade-off between privacy and safety is empirically addressed as well as different locations of surveillance and different camera types are taken into account. Comparing a medical and a surveillance context allows to find out if the acceptance of surveillance technologies is a context-sensitive phenomenon. This way, it is examined to what extent city residents' evaluation of the trade-off between safety and privacy varies depending on the context, the type of technology, and the city location in which surveillance is applied.

2 ACCEPTANCE OF SURVEILLANCE SYSTEMS

Currently, more and more different surveillance technologies are used and integrated into surveillance concepts not only to generate smart houses, but also to build smart city networks. Thus, this section presents an overview of the technologies that are applied for different surveillance contexts as well as their advantages and drawbacks (2.1). Further, the current state of the art concerning research on the acceptance of surveillance is detailed focusing on which technologies are accepted at which locations, for which context, and under which conditions (2.2).

2.1 Context-specific Use of Surveillance Technologies

For the context of crime surveillance, the currently most applied safety measure in urban environments is video surveillance (Koh et al., 2016). Video surveillance strongly differs with respect to the camera type enabling diverse functions (compounded with other technologies) such as face recognition or precise location determination. These types of video surveillance are used in many cities exhaustively enabling a detailed tracking of criminals and detection of crimes (La Vigne et al., 2011). Some theoretical research approaches focus also on the integration of crime surveillance into smart city concepts (Fyfe, 2004; Dey et al., 2012). So far, many studies investigated the effectiveness of safety measures such as improved lighting of public places or video surveillance for enhancing safety especially at public high-frequented locations (e.g., La Vigne et al., 2011, Welsh & Farrington, 2004; Welsh et al., 2015): all of them found an increased safety perception by city residents but also a higher "real" safety in terms of crime reduction and higher rates of crime detection. In contrast, an invasion of privacy is the main drawback of (video-based) crime surveillance as recording, processing, and storage of data is heavily scrutinized (e.g., Welsh et al., 2015; Schwartz, 2012).

For medical reasons, surveillance technologies were mainly used in the private home environment, in health facilities, and retirement homes in the last years. A wide variety of AAL technologies exists mainly developed to detect falls and enable fast assistance in emergencies (Cardinaux et al., 2011; Memon et al., 2014). Using video-based technologies is in particular advantageous as it enables contactless observation without the necessity to equip patients with further technologies (e.g., help button, tag, sensors). Thus, a high number of video-based health surveillance systems was developed to date that primarily focus on fall detection in order to increase safety (e.g., Fleck & Strasser, 2008; Yu et al., 2012; Chen et al., 2013). Although AAL technologies were predominantly used at private environments, it is reasonable to integrate medical surveillance technologies at public urban environments to expand existing (crime) surveillance technologies with regard to medical surveillance as a high number of emergencies happen in public. In accordance with demographic change and an aging society, the needs for public medical surveillance in cities increase continuously. Hence, there are also first approaches to integrate medical or health surveillance into smart city concepts in order to increase medical safety (Solanas et al., 2014).

Besides the main benefit of increased safety, privacy concerns are of major importance in the health or medical surveillance context (Wilkowska & Ziefle, 2012). In particular, privacy is a highly relevant topic for video surveillance, since people in the area covered by cameras have no option to avoid being monitored. There are some technical approaches that try to integrate measures to protect privacy within the surveillance systems, e.g., by recording and storage of video data only if accidents were detected (Aghajan et al., 2007).

Summarizing so far, the use of surveillance technologies implies a sensitive and critical trade-off between an increase in safety and the protection of privacy in a crime as well as a medical surveillance context.

2.2 Technology Acceptance

Usually, the development and integration of surveillance technologies is a policy decision of planning authorities in cities and communes without integrating residents during the technical development and decision-making process. However, the controversial public discussion about surveillance shows that it might be supportive to consider resident's needs and concerns in early phases of the decision process in order to enable a pleased and safe life in cities (Slobogin, 2003; Surette, 2005). While there are a plenty of studies focusing on technical characteristics of surveillance or the efficiency of applied surveillance technologies (e.g., La Vigne et al., 2011; Welsh et al., 2015), sparse social science research is available in this regard. Previous acceptance studies primarily focus on single surveillance contexts: a study on crime surveillance acceptance found highest acceptance scores for video surveillance at highly frequented public places, such as train stations, as well as comparatively higher needs for safety at public and higher privacy needs at private environments (van Heek et al., 2015). Another single case study focused on medical surveillance and also found higher acceptance scores for video surveillance at public environments. However, general acceptance for medical surveillance was rather low due to strong privacy concerns of the participants (Himmel et al., 2013).

A direct comparison of different surveillance contexts has not been investigated so far. It would be useful to analyze whether the acceptance of surveillance technologies and the evaluation of the trade-off between safety and privacy is a generic or a context-sensitive phenomenon. As privacy and safety proved to be important factors of surveillance acceptance (see 2.1), their understanding is essential for a successful adoption of surveillance technologies (Rogers, 2003).

The Technology Acceptance Model (TAM) is the most known and best-established model explaining and predicting the adoption of technologies and serves as a basis for numerous subsequent and adapted models (Davis et al., 1989). However, these acceptance models cannot be simply applied to the acceptance of video-based surveillance technologies: A first reason is that conventional acceptance models enable an evaluation of complete technologies, systems, or applications, but they do not allow an evaluation of single technical functions or characteristics of a system. Hence, it is not possible to derive which characteristics of a system lead to adoption or non-adoption of the complete system yet. As a result, it is also not possible to derive concrete design guidelines, e.g., where, how, and under which conditions a video-based surveillance system should be used. Secondly, questionnaires, designed on the basis of TAM or adapted acceptance models, do not allow a simulation of complex decision scenarios, in which several decision criteria are weighted against each other. Hence, it is also not possible to infer statements about relative importance, relationships, and interactions of several factors.

Summarizing, acceptance, conceptualization, and integration of video-based surveillance systems in smart cities could be improved, if designers and (city) planners could revert on city residents' preferences. Thus, the goal of our study was to capture preferences for video-based surveillance scenarios at different locations (private vs. public), under consideration of different camera types, benefits in terms of increased safety, and privacy concerns due to different data handling purposes. By applying a conjoint analysis, decision scenarios were simulated and different attributes' acceptance as well as their interrelations were analyzed in detail. In order to fulfill a direct comparison of surveillance context, the approach was carried out for a medical (study 1) and a crime surveillance (study 2) context.

3 METHODOLOGY

In order to understand if acceptance for surveillance depends on the context, the conjoint analysis approach was applied to a medical and a crime surveillance scenario. The factorial design of the conjoint analysis in both contexts (surveillance vs. medical) included four attributes that had been identified as important impact factors on surveillance acceptance in preceding studies (van Heek et al., 2015; Arning & Ziefle, 2015): 1) locations of surveillance, 2) increase in safety operationalized as detection rates of crimes and medical emergencies, 3) privacy in terms of different handlings of the recorded data material, and 4) different camera types. These attributes were used to identify the most important parameters and to examine to which extent surveillance scenario decisions based on these attributes were linked to the surveillance context.

3.1 Conjoint Analysis

Conjoint analyses were developed by Luce and Tukey in the 1960s and combine a measurement model with a statistical estimation algorithm (Luce & Tukey, 1964). Within a conjoint analysis, respondents assess specific product or scenario configurations that consist of different attributes and differ from each other in the attribute levels. This way, conjoint analyses go beyond the possibilities of conventional survey-based research approaches: they enable not only an evaluation of single product or scenario characteristics, but allow a holistic evaluation of decision scenarios, a weighting of different attributes against each other, and a direct simulation of relationships and interactions (Orme, 2010). Decision processes and scenario preferences can be simulated and separated into part-worth utilities of the attributes and their levels. In this process, the relative importance of attributes delivers information about which attribute affects the participants' choice the most. The part-worth utilities characterize the most important or unimportant attribute levels. Further, preference ratings and preference shares can be consulted as indicators of acceptance.

For this study, a choice-based conjoint analysis approach (CBC) was chosen in order to analyse scenario decisions in which - most probably - more than one attribute affects the final respondent's choice (Sawtooth Software, 2009).

3.2 Attributes and Attribute Levels

The identification and selection procedure of attributes and attribute levels is the first - and highly important - step for the conceptualization of a conjoint analysis, since it affects the generalizability, validity, and significance of the findings (Rao, 2014). It has to be ensured that all attributes are considered that are relevant for the preferences of respondents as well as for city-planers, policy-makers, or other important stakeholders. In order to identify the attributes, the results of extensive literature analyses and preceding studies were used - in which relevant parameters for the acceptance of surveillance technologies (crime surveillance (van Heek et al., 2015) and medical surveillance context (Arning & Ziefle, 2015)) were identified as a basis for the selection of attributes and levels.

The following four attributes were assessed in our conjoint study: locations of surveillance, camera types, increase in safety, and invasion of privacy.

Within the attribute *locations*, the private home environment was contrasted with different public locations as place for camera installation: store, market, and train station.

Increase in Safety as major benefit of implemented surveillance technologies was operationalized as different detection rates of crimes in the crime surveillance and of medical emergencies in the medical surveillance context. The attribute levels were specified as detection rates of 0% (no improvement), 5%, 10%, and 20% in both contexts.

Invasion of Privacy as major concern of implemented video-based surveillance technologies was operationalized as different ways and intensities to handle and process recorded video data and included the following levels: merely archiving data (police and patient data bases), storage in profile data bases (open to institutions, e.g., health insurance companies, security services), enabling position determination, and allowing face recognition.

As last attribute *Camera Type* was integrated into the study differing in size, visibility, an obtrusiveness of the technology: a conventional, clearly visible, large and tracking camera, a large and visible dome-camera, a small mini-dome-camera, and a hidden, integrated, not visible camera.

3.3 Conjoint Questionnaire Design

In both contexts - medical (study 1) and crime (study 2) - identical questionnaire designs were developed using the SSI web Sawtooth Software (SSI Web, 2016) and consisted of four parts.

The first part addressed demographic characteristics such as age, gender, educational level, type of residence, and area of residence. Afterwards, the participants had to answer some context-specific questions. For the medical surveillance context, the participants were asked for details concerning health status and experience with medical emergencies. For

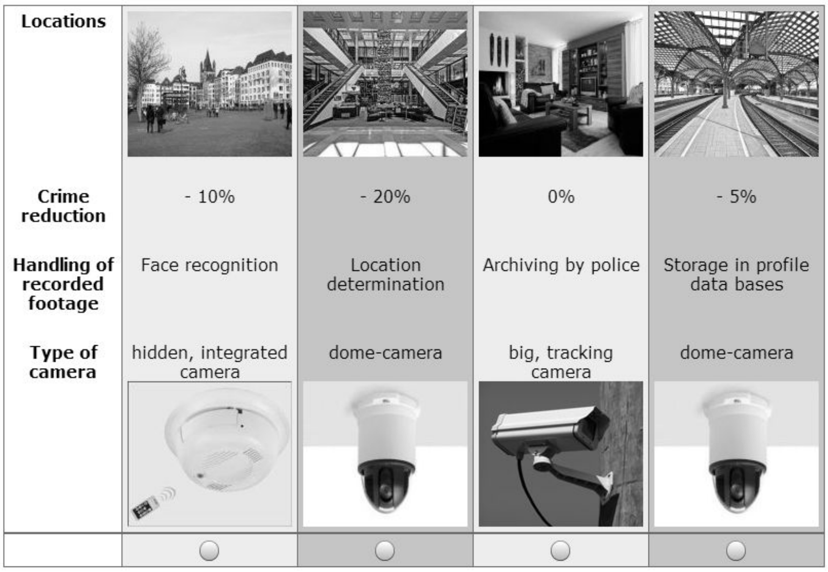

Figure 1: Example of a choice task (crime surveillance context).

the crime surveillance context, the participants indicated if they have already fallen victim to offenses.

In the second part, the respondents indicated their perceived threat (of crimes or medical emergencies) and their needs for privacy (measured each with four items on six-point Likert scales). The items were checked for reliability and subsequently summed up resulting in a “need for privacy” and a “perceived threat” score.

Next, the participants were introduced in the respective scenario. The medical scenario dealt with the installation of video cameras for medical surveillance purposes at different locations. The cameras were able to sent an emergency signal to a medical institution. Similarly, the cameras introduced in the crime surveillance scenario were also installed at different locations and should help to detect and prevent crime by enabling to send alarm signals to security institutions.

In the fourth part, the CBC choice tasks with four attributes and each four levels were presented. As a control, the participants were asked to imagine that they would be alone during the day. Then, they should decide under which conditions and at which locations they would accept the installation of video cameras and were instructed to select the scenario in each choice task, that met their individual needs most closely. An example for a choice task is shown in Fig. 1. As a combination of all attribute levels would have let to 256 possible combinations (4x4x4x4), the number of choice tasks was reduced and overall, 10 random and one fixed task were presented to the participants. A test of design efficiency confirmed that the reduced, randomized design was sufficient and comparable to the hypothetical orthogonal design regarding a sample of at least 100 respondents.

3.4 Data Analysis

For analysing the conjoint data (i.e. estimation of part-worth utilities, preference simulations) the Sawtooth Software was used (SSI Web, 2016)(SMRT, 2016). First, the relative importance of attributes was calculated, that deliver information about which attribute affected the participants’ choice the most. The computed part-worth utilities of all attribute levels characterize the most important or unimportant attribute levels. Finally, preference simulations were run estimating the impact on preferences if single attribute levels change within a predefined specific scenario (Orme, 2010). Preference ratings and shares can be interpreted as indicators of acceptance. Data was analysed descriptively and, with respect to the effects of surveillance context and user diversity, by (M)ANOVA procedures (significance level at 5%).

3.5 Sample Study 1 and 2

Data was collected in an online survey in Germany and completion of each questionnaire took on average 15 minutes.

In *study 1*, overall 119 participants fully completed the questionnaire and were included in statistical analyses. 52.9% of these participants were female and 47.1% male. The mean age was 28.5 years (SD=11.7) and ranged from 18 to 75 years. The educational level was high with 38.7% of participants holding a university degree and 45.4% a qualification for university entrance. The participants' majority lived in apartment buildings (60.5%, n=79), while far fewer people indicated to live in detached (14.3%), semi-detached (4.2%), or row houses (15.1%). Most of the participants lived in the city centre (60.5%), 23.5% on the outskirts, 7.6% in suburbs, and 8.4% in a village. Further, 29.4% of the participants indicated to have no experiences with medical emergencies at all. Nearly half of the participants (48.7%, n=58) reported to have already experienced a medical emergency in their family and 15.1% have been in a medical emergency situation themselves. Participants indicated to feel only little threatened by medical emergencies (M=2.3; SD=1.1; min=1; max=6), but showed very high needs for privacy (M=5.5; SD=0.6; min=1; max=6).

In *study 2*, 130 participants completed the questionnaire and were included in further statistical analyses. 60.0% of the participants were female, 40.0% were male. The mean age was 32 years (SD=12.2), ranging from 16 to 77 years. The educational level was also high with 48.5% holding an university degree and 26.9% an university entrance qualification. Similar to study 1, the majority of participants lived in apartment buildings (60.0%), and far fewer people lived in a detached (20.0%), a semi-detached (6.9%), or a row house (13.1%). 43.1% of the participants lived in a city centre, while 22.3% lived on the outskirts, 20.0% in suburbs, and 14.6% in a village. 32.3% (n=42) had no experiences with crimes at all, while 67.7% had a least fallen victim to "slight" offenses (e.g., theft). On average, participants indicated to feel only slightly threatened by crime (M=2.5; SD=0.9; min=1; max=6). Similar to study 1, the participants of study 2 showed very high needs for privacy (M=5.5; SD=0.6; min=1; max=6). ANOVAs revealed that the samples of study 1 and 2 did not differ regarding gender, educational level, type of residence, perceived threat (of crimes or emergencies), previous experiences, and privacy needs. However, the results showed significant differences only for *age* (F(1,248)=5.389; p<.05) and *place of residence* (F(1,248)=10.436; p<.05): compared with study 1, the participants of study 2 were on average a little older and lived more often outside the city centre.

4 RESULTS

First, the relative importance of attributes is presented for the medical and crime surveillance context. Afterwards, the part-worth utilities are presented for all attribute levels comparing medical and crime surveillance. Further, the results of preference simulations analyses with regard to the trade-off between safety and privacy are described.

4.1 Context-Specific Acceptance Factors

The relative importance of attributes was calculated for the medical and the crime surveillance context and is shown in Figure 2.

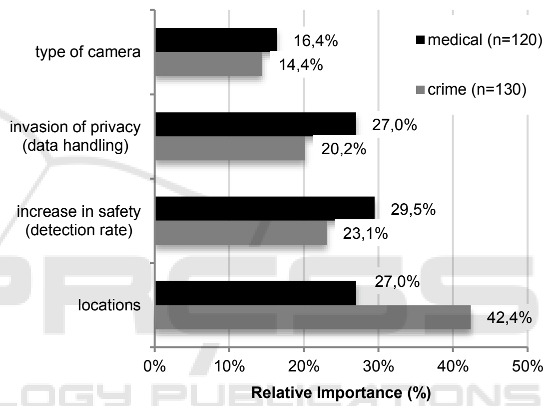

Figure 2: Relative importance of attributes for medical and crime surveillance.

Overall, (M)ANOVA analyses revealed significant differences between the medical and the crime surveillance context concerning the relative importance of the attributes (F(4,249)=21.610; p<.01). For the medical surveillance context, *increase in safety* was the most important attribute (29.5%), directly followed by *invasion of privacy* and *locations of surveillance* (each 27.0%), which were also very important. The *camera type* is comparatively the least important attribute (16.4%) for medical surveillance scenarios.

This is in line with the crime surveillance scenario results, where *camera type* was the least important attribute (14.4%) as well (F(1,249)=2.725; p=.10; n.s.). Concerning the other three attributes, a more heterogeneous picture emerged: in contrast to the medical surveillance scenario, *locations of surveillance* was the most important attribute for scenario decisions (F(1,249)=79.588; p<.01), followed by increase in safety (23.1%) (F(1,249)=12.300; p<.01),

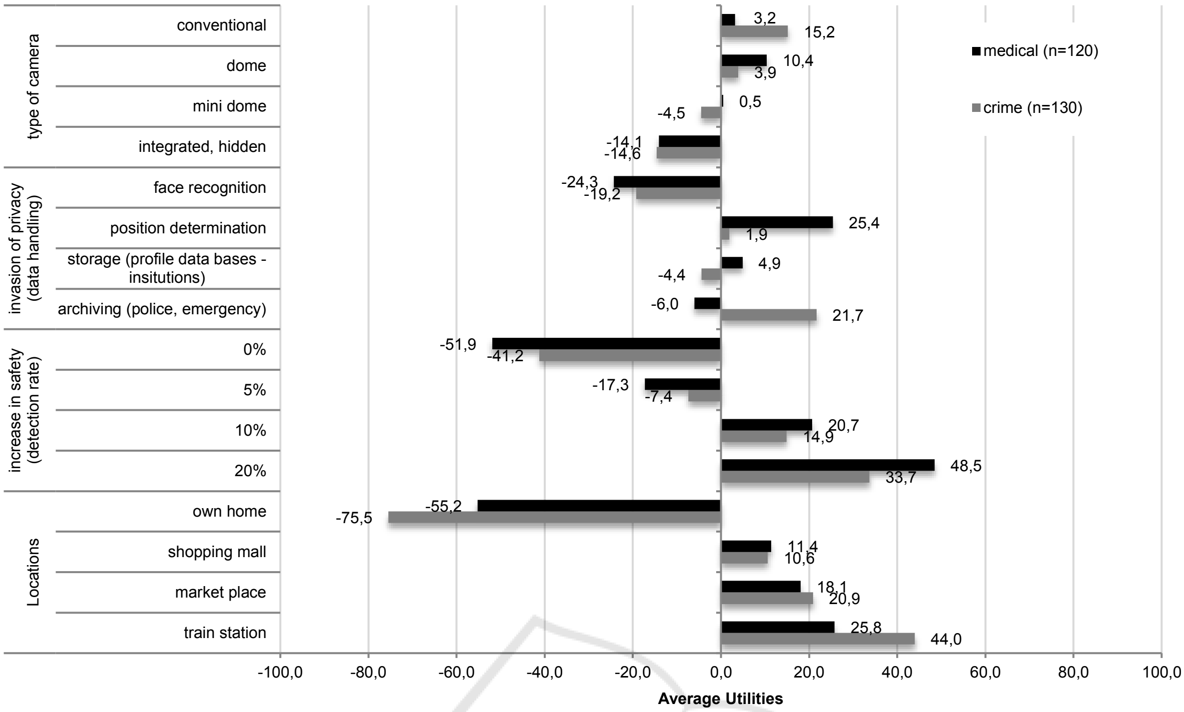

Figure 3: Part-worth utilities of all attribute levels for medical and crime surveillance.

and invasion of privacy (20.2%) (F(1,249)=13.908; p<.01) which were of similar importance in the crime surveillance scenario.

4.2 Context-Specific Acceptance Characteristics

MANOVA analyses were calculated for each attribute level as dependent and the surveillance context as independent variable. Figure 3 presents the results of the part-worth utilities for medical and crime surveillance.

The results showed a similar evaluation pattern across scenarios, however, also significant differences for the attribute *locations*, (F(3,245)=4.055; p<.01): surveillance at a store (F(1,248)=0.058; p=.85; n.s.) or a market (F(1,248)=0.063; p=.42; n.s.) revealed both rather positive utility values independent of the surveillance context.

In contrast, surveillance at a train station received a significantly higher utility value in the crime context (44.0) than in the medical context (25.8) (F(1,248)=11.914; p<.01), while surveillance at the own home received a clearly lower utility value for the crime (-75.5) than the medical (-55.2) context (F(1,248)=5.878; p<.05).

The evaluation pattern of the *increase in safety* attribute levels was similar for both contexts, but differed with regard to the amounts of values (F(3,245)=3.770; p<.05) due to the higher attribute's importance for the medical surveillance context: detection rates of 0% (F(1,248)=4.809; p<.05) and 5% (F(1,248)=9.986) obtained more negative utility values for the medical (0%: -51.9; 5%:-17.3) compared to the crime surveillance context (0%: -41.2; 5%: -7.4). Instead, detection rates of 10% (F(1,248)=5.455; p<.05) and 20% (F(1,248)=8.176; p<.01) received obviously higher positive utility values for the medical (10%: 20.7; 20%: 48.5) than the surveillance context (10%: 14.9; 20%: 33.7).

The most diverse evaluation pattern emerged for the *invasion of priv*acy attribute levels (F(2,244)= 13.047; p<.01). As the worst way of data and privacy handling, face recognition achieved negative utility values regardless of the surveillance context (F(1,248)=0.906; p=.34; n.s.). For the crime surveillance context, archiving of data (by police and emergency services) obtained the highest positive utility values (21.7), while it received slightly negative values for the medical context (-6.0) (F(1,248)=25.444). Storage of data in profile data bases (by medical or crime institutions) was rated with rather positive utility values for the medical (4.9), but with rather negative values for the crime (-4.4) surveillance context (F(1,248)=4.143; p<.05). Finally, position determination received the highest positive utility values for the medical (25.4) and only neutral values for the crime (1.9) surveillance context (F(1,248)=19.282; p<.01).

The levels of the attribute *camera type* were partly rated differently for both contexts (F(4,244)=3.202; p<.05). The hidden and integrated camera received high negative utilities for both groups (F(1,248)=0.027; p=.83; n.s.). Further, the mini-dome camera was not evaluated differently as well (F(1,248)=2.740; p=.1; n.s.). The dome camera obtained slightly positive values for the crime (3.9), but the attribute's highest positive values for the medical (10.4) surveillance context (F(1,248)=8.323; p<.01). In contrast, the conventional large and tracking camera received the highest utility values for the crime (15.2) and only slightly positive values for the medical (3.2) surveillance context (F(1,248)=7.018; p<.01).

4.3 Safety Vs. Privacy Decisions

Overall, the results (see 4.1) showed that the safety and privacy attributes were significantly more important for medical than for crime surveillance. What both contexts have in common is that there is no clear distinction concerning the importance of the safety and the privacy attribute (Fig. 2).

To examine the trade-off between increase in safety and invasion of privacy in detail, sensitivity analyses were carried out using the Sawtooth market simulator (SMRT, 2016). In these simulations, it is possible to examine to which extent respondents' relative preferences for a scenario change if the levels of an attribute vary while other specific attribute levels were kept constant. To directly contrast safety and privacy, two opposite safety and privacy scenarios with constant attribute levels were formed, based on the findings of the previously reported part-worth utilities:

1. *high increase in safety + high invasion in privacy*: with the constant levels "detection rate of 20%" and "face recognition"
2. *low invasion in privacy + low increase in safety*: with the constant levels "detection rate of 0%" and "archiving of data"

These levels were kept constant while all other attribute levels (locations and camera type) changed. The results are pictured in Fig. 4 for the medical and in Fig. 5 for the crime surveillance context.

For the medical surveillance context (Fig. 4), the "high safety" scenario (max. 61.6%) reached higher average preferences compared to the "high privacy" scenario (max. 20.2%). For all single attribute levels in the medical surveillance context, the preferences were significantly higher for the "high safety" than for the "high privacy" scenario. The acceptance of the "high safety" and also of the "high privacy" scenario rose, when surveillance was carried out at public locations. Changing the attribute level from private home (32.9%) to a public location (store: 57.5%) in the high safety scenario, caused the highest difference in the share of preference (+24.5%), while the differences between the various public locations were rather small. Concerning all camera types in the medical surveillance context, the "high safety" scenario was consistently favoured by at least 49.7% difference.

Overall, the decisions in the crime surveillance context showed a similar pattern (Fig. 5). The "high safety" scenario (max. 66.5%) was clearly preferred compared to the "high privacy" scenario (max. 20.0%) for all attribute levels (locations and camera types) except of surveillance at the private home environment ("high safety": 15.3%; "high privacy": 14.3%). Here, surveillance for crime detection reasons was not desired and accepted regardless of different safety and privacy scenarios. Similar to the results in the medical surveillance context, the highest difference (+46.3%) occurred in the "high safety" scenario, when surveillance at the private home (15.3%) was changed to a public location (store: 51.6%). In the "high privacy" scenario, there were only small differences between the various locations and almost no differences between the camera type

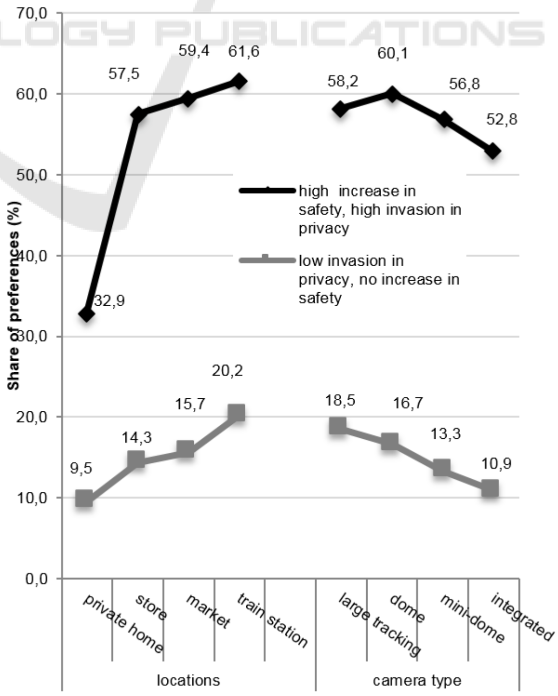

Figure 4: Results sensitivity analyses for medical surveillance.

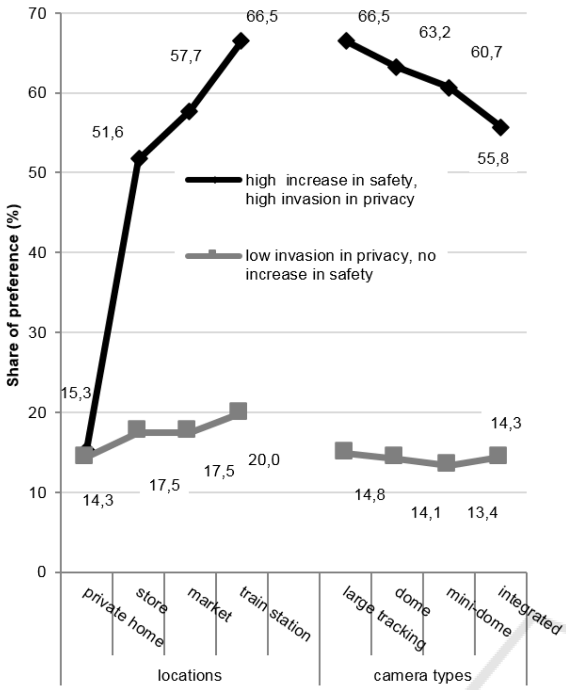

Figure 5: Results sensitivity analyses for crime surveillance.

levels. In contrast, the camera types were evaluated differently in the "high safety" scenario: the large tracking camera obtained the highest share of preferences (66.5%), while less visible cameras received lower agreement (e.g., the invisible, integrated camera 55.8%).

5 DISCUSSION

This study revealed insights into the acceptance of surveillance technologies for two different surveillance contexts. Using a conjoint analysis approach and involving the location of surveillance, the applied camera type, and the trade-off between safety and privacy as acceptance parameters, decision scenarios were simulated for a medical and a crime surveillance context. The results showed which acceptance parameters are relatively most important and which characteristics lead to adoption or non-adoption of surveillance technologies in urban environments. The findings provide valuable insights for the conceptualization and planning of smart cities regarding an acceptable implementation and use of surveillance technologies in urban environments.

5.1 Context-sensitive Acceptance of Surveillance Technologies

For the crime surveillance context, the location of surveillance clearly is the most important determinant of surveillance acceptance, while increase in safety and protection of privacy are of secondary importance. In contrast, these three parameters are nearly of equal importance for medical surveillance. One explanation for the greater importance of locations in the crime surveillance context could be that crimes were stronger associated with special locations than medical emergencies. In contrast, for medical surveillance, the interaction of perceived benefit (increased safety, perceived barrier (privacy), and location of surveillance is important. What both contexts have in common is that the applied type of camera technology is comparatively unimportant in relation to the other three aspects. In contrast to previous studies, which identified safety and protection of privacy as important factors for acceptance without weighting them directly (Slobogin, 2002; Welsh and Farrington, 2009; Welsh et al., 2015), this study revealed that acceptance depends on perceived benefits in terms of increasing safety and to a slightly lesser extent on privacy-related issues. The rather similar evaluation of safety and privacy for both contexts shows the importance to analyse this trade-off in detail and to consider this complex phenomenon in future studies as well as conceptualizations of surveillance systems in urban environments.

5.2 Context-sensitive Characteristics of Acceptance

Confirming previous research results (e.g., Welsh & Farrington, 2009), the use of surveillance technologies is generally accepted at public locations in urban areas. In contrast, our findings demonstrate that surveillance technologies are not accepted at all at private locations such as the own home. Interestingly, the same acceptance pattern was found for the crime as well as the medical surveillance context. Although previous research also indicated this pattern for medical surveillance (Himmel et al., 2013), we assumed differences between both contexts and preferences for the home environment in the medical context as most AAL technologies were used and were planned to be used in private home environments.

Concerning the increase in safety, a similar acceptance pattern was found for both surveillance contexts as well. The pattern was merely a bit stronger pronounced for the medical surveillance context due to the higher relative importance of the attribute: the higher the detection rates and thus, the increase in safety, the higher the acceptance. Low detection rates of 0% or 5% were completely rejected. Hence, the perceived benefit of surveillance (increased safety) has to be noticeable for acceptance and is more important for the medical than the crime surveillance context.

The most contrary acceptance pattern was revealed for the privacy attribute. For the medical surveillance context, position determination is the best evaluated way of handling video data, which is in line with previous research results. Archiving and storage of recorded data is not desired for medical surveillance. In contrast, archiving of data is the most desired way of data handling in the surveillance context. Interestingly face recognition is perceived as invasion in privacy and is the most rejected way of data handling for medical as well as crime surveillance.

Although the camera type was relatively unimportant, a tendency of preferences for both contexts can be derived: for crime surveillance, conventional large cameras are preferred, while a bit smaller and discrete cameras are desired for medical surveillance. However, hidden and integrated camera technology is strictly rejected for both surveillance contexts. This is surprising and has to be considered, as current technological developments – in particular in the field of AAL environments – aim for designing small, less visible or invisible and seamlessly integrated technologies (e.g., Kim et al., 2012).

5.3 Trade-off between Safety and Privacy

Previous research results on the trade-off between privacy and safety indicated that the will to abandon a piece of privacy for increased safety depends on the degree of increased safety (Bowyer, 2004). Our study revealed that only a noticeable increase in safety (detection rate at least 10%) is perceived positively independent of the surveillance context. Although, the analysis of relative importance revealed only slightly higher importance of increase in safety (crime: 23.1%; medical: 29.5%) in contrast to the privacy attribute (crime: 20.2%; medical: 27.0%), the sensitivity analyses showed that secure scenarios were clearly preferred compared to scenarios that focused on privacy.

Thus, safety is much more preferred in a direct confrontation of safety and privacy for medical as well as crime surveillance. Thus, safety issues are more important criteria for the acceptance of surveillance technologies than privacy issues, provided the technology is efficient and causes a noticeable increase in safety.

5.4 Limitations and Further Research

Although, the applied conjoint analysis approach was useful to evaluate preferences in different surveillance scenarios and enabled a comparison of surveillance, there are some limitations that should be considered for further studies.

A first limitation is that the estimated preference ratings are ratings on a hypothetical level and do not mirror actual behaviour. Hence, agreement or rejection might be higher or lower in real situations (Ajzen & Fishbein, 1977). A second limitation affects the limited number of attributes in a choice-based conjoint analysis. It had to be found the right balance between an economic research design with a limited number of attributes and a not to high complexity of the research issue. The participants suggested other interesting attributes, which could be integrated in future research, such as the period of data storage.

Further, there are some limitations with respect to the samples of this study. So far, a highly educated participants group was examined. It is not clear if the results can be simply transferred to other education levels, therefore, future studies will aim at samples with a more diverse educational level. In addition, the samples did not have much experience with crime offenses and medical emergencies. Hence, it cannot be excluded that the trade-offs between safety and privacy are quite theoretically evaluated, without the true understanding of own experience.

As the approach focused on video-based surveillance, it would be useful to analyse the acceptance of other surveillance technologies with respect to different surveillance contexts in detail.

Further, it is assumed that the evaluation of surveillance technologies is influenced by current events such as terrorist attacks and crimes in the local environment. Hence, longitudinal studies and comparisons of surveillance acceptance represent an interesting approach for further research.

Finally, as the approach represents the acceptance of surveillance with a perspective of a single country, it would be useful and interesting to compare surveillance needs and wishes of city residents of different countries, backgrounds, and cultures.

ACKNOWLEDGEMENTS

The authors thank all participants for their patience and openness to share opinions. Furthermore, the authors want to thank Valentina Kneip for research assistance. This work was funded by the Excellence Initiative of the German State and Federal Government (Project Urban Future Outline).

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