"How Fear of Crime Affects Needs for Privacy & Safety"
Acceptance of Surveillance Technologies in Smart Cities

Julia van Heek, Katrin Arning and Martina Ziefle
Human-Computer Interaction Center, RWTH Aachen University, Germany

Keywords: Technology Acceptance, Crime Surveillance Technologies, Privacy, Safety, Smart Cities, Perceived Crime Threat.

Abstract: These days, surveillance technologies are a key component of smart and networked cities preventing or detecting crime and giving the residents a sense of safety. On the one hand, safety perceptions can be supported by adequate surveillance technologies (e.g., cameras), however on the other hand, the systematic use of surveillance technologies undermines individual privacy needs. In this empirical study, we explore users' perceptions on safety and privacy in the context of surveillance systems in urban environments. Using an online survey, 119 users were requested to indicate their acceptance regarding different types of surveillance technologies, differentiating perceived benefits and barriers as well as safety and privacy needs. Also, we investigate acceptance differences towards surveillance technologies at various locations (private and public). In this paper, we especially explore the impact of individual perceived crime threat on the acceptance of surveillance technologies and on the needs for privacy and safety.

1 INTRODUCTION

One of the major challenges of modern societies is to meet the complex demands of urbanization processes and to maintain liveable, sustainable, and smart cities. Up to 2030, more people will live in cities than in other regions and this development is forecasted to increase further. In line with these fundamental urbanization processes, consecutive challenges arise. Beyond issues of economy, transportation or governance, nowadays' major keystones of urban planning are the broadly accepted implementation of technical infrastructures and (smart) city concepts (Ziefle et al., 2014). All over the world, an increasing number of surveillance technologies is used to prevent or time-critically detect crime in order to improve safety (La Vigne et al., 2011). Perceived safety represents an essential prerequisite for the participation in social and economic life and is a valuable good for cities. However, the main drawback of surveillance technologies is the perceived privacy violation by the public through the recordings and processing of data (Whitaker, 1999). Therefore, smart city concepts must meet a wide range of residents´ needs, including high comfort regarding safety, sustainability, but also consider different levels of perceived crime threat, and protection of privacy (Ziefle and Wilkowska, 2015).

Facing the demographic change, smart city concepts should also address the diversity of urban residents. Although they are essential for all dwellers, especially different ages of residents should be taken into account. If individual needs and wishes of both younger and older people are considered, the fundament for liveable and safe future cities is granted (Plouffe and Kalache, 2010).

2 ACCEPTANCE OF CRIME SURVEILLANCE SYSTEMS

For a free, unrestricted and unworried life in urban areas, people need to feel safe. In this context, crime threat in cities is a central challenge (Smith and Clarke, 2000; Marshall et al., 2007). The consequences of crime for urban safety and individual risk perception are well described and represent a serious barrier for many residents (e.g. Baumer, 1978; Loewen et al., 1993). While it is undisputed that safety and crime prevention are major goals for urban development, the realization of effective

Heek, J., Arning, K. and Ziefle, M.
"How Fear of Crime Affects Needs for Privacy Safety" - Acceptance of Surveillance Technologies in Smart Cities.
In *Proceedings of the 5th International Conference on Smart Cities and Green ICT Systems (SMARTGREENS 2016)*, pages 32-43
ISBN: 978-989-758-184-7

safety measures is controversially evaluated (Isnard, 2001/Wiecek and Seatnan, 2002/Sheldon, 2011).

Technically, surveillance technologies are at hand and are already widely used in urban environments to increase safety (Chattopadhyayr, 2013/ Song et al., 2013). Most of all city centers use close-circuit television in public spaces and in public transport systems. However, the acceptance of these systems in general and, more specific, the individual perception of safety does not necessarily rise, when surveillance systems are installed (Lewis and Maxfield, 1980). Instead, perceived fear of crime in urban environments is rather shaped by physical features, such as visibility or lighting, prospect such as open spaces, opportunities to escape (Blöbaum and Hunecke, 2005). But not only physical characteristics of urban spaces, but also perceived incivilities in surrounding areas strongly affect fear of crime (Lewis and Maxfield, 1980). Therefore, the installation of technical safety measure needs to carefully address individual perceptions of safety at different locations to support safe living in smart cities.

Apart from the goal of enhanced safety, surveillance systems also pose ethical concerns. In terms of privacy, protection is one of the key human rights. Technical monitoring of people in urban environments for safety reasons conflict with individual rights for privacy (Gumpert and Drucker, 2001), which – beyond legal concerns – might lead to a public rejection of monitoring technologies in city locations (Arning et al., 2013b). Accordingly, the relationship between individual needs for safety from crime and the individual need for protecting one's own privacy is complex and does not follow a simple arithmetic, but rather varies with usage context, individual characteristics and city needs (Arning et al., 2013a). The safety-privacy-relationship for crime surveillance technologies can only be understood if the trade-off between both basic motives is empirically addressed.

3 INDIVIDUAL FACTORS

The population in cities is characterized by a high heterogeneity. Residents' needs and wishes towards quality of city life as well as related experiences and attitudes are affected by a multitude of individual factors. Though there are individual key characteristics, which allow defining groups with specific needs regarding safety and privacy. One important factor is age, which becomes even more relevant with the on-going demographic change. For instance, age-related changes in health conditions and changed leisure time activities after retirement lead to specific mobility and accessibility needs (Alsnih and Hensher, 2003). Especially for older people, perceived safety in their living environment is essential for maintaining social contacts (Dickerson et al., 2007). Apart from age, gender is another factor, which strongly affects needs for safety and privacy. Elderly women, for example, have higher needs for safety than men, reducing their willingness to use public transport-tation or carpooling (Arning et al., 2013b). Beyond age and gender, but strongly interrelated, the perceived level of crime fear is another important factor for the acceptance of surveillance techno-logies in smart cities. Fear of crime, defined as the emotional response to possible violent crime and physical harm (Covington and Taylor, 1991), has been intensively researched in the last decades by various scientific disciplines in the context of urban development. Two central findings are specifically noteworthy in this context: a) crime fear is an individual perception not necessarily associated with objectively measurable crime statistics. Thus, even when persons live in a comparably safe residence, they might perceive higher levels of crime fear; b) individual factors, as age, gender, and experience with crime, further affect fear of crime. A well-replicated finding in this context is the inverse relationship of victimization rate and crime fear: the most fearful individuals (elderly women) have the lowest victimization rate, the least fearful (young men) have the highest victimization rate (Scarborough et al., 2010). The strong interrelations of age, gender and crime fear suggest, that age and gender serve as "carrier variables" for different levels of perceived crime fear. Accordingly, the present study focuses on the inter-individually different effects of crime fear on surveillance technology acceptance.

The usage of crime surveillance technologies in urban environments is one (technical) approach to enhance perceived safety and to reduce crime rates. Yet, only sparse knowledge is available about acceptance patterns of residents towards benefits and barriers of crime surveillance technologies, which are assumed to increase safety perceptions in the context of smart cities. The goal of the present study is, thus, to understand peoples' acceptance of crime surveillance technologies in urban environments, taking needs of safety and privacy as well as individual factors such as perceived crime threat into account.

4 METHODOLOGY

In the following section, the questionnaire, the sample and the applied statistical procedures are detailed.

4.1 Questionnaire

Questionnaire items were developed based on the findings of focus group interviews carried out prior to this study. The questionnaire was arranged in six sections. The *first part* addressed demographic characteristics of the participants, namely age, gender, family status, children status, number of persons living in a household together, type and place of residence, housing status (homeowner or tenant), educational level, (current or last) job sector and current or last occupation.

The *second part* focused on the individual perception of crime threat (PCT) and potential experiences with crime. First, we asked for PCT at different places by day and by night. For clarity reasons, locations were arranged into four categories (*private* (e.g., garden), *semi-private* (e.g., own street), *semi-public* (e.g., shopping mall), and *public* (e.g., train station) locations) based on results of previous focus groups interviews. The question "to what extent do you feel threatened by crime during the day?" had to be evaluated for more than 20 different public and private locations (see Fig. 1). Threat perceptions had to be rated on a six-point Likert scale (1=not at all; 6=very strong PCT). In addition, looking for possible differences of PCT during day- and nighttime, participants had to evaluate on a five-point scale (-2=much lower; -1 =lower; 0=no difference; 1=higher t; and 2=much higher) if they would feel a different crime threat at the same locations by night.

Based on PCT ratings for different locations the between-factor "perceived crime threat" (PCT) was calculated. Respondents' PCT ratings were summed up (max=156), transformed to a value of 100 and a median split was conducted (cut-off=34.62), which separated two groups with low PCT and high PCT.

Second, we asked for individual crime threat concerning different crime offenses, which had to be evaluated by the participants on a six point Likert scale. The final aspect of this part of the questionnaire focused on experiences with crime. Here, participants indicated whether they, their family, friends, relatives or acquaintances had become victims of various crimes offenses themselves, e.g. theft or bodily injury.

The *third part* assessed technologies and traditional measures enhancing perceived safety in private and public environments. Thus, different technologies (e.g., camera surveillance, ambient lighting, microphones) but also social measures (e.g., police presence) had to be rated on a six-point Likert scale (1=strongly disagree; 6=strongly agree) for a private as well as a public context of use.

The *fourth part* of the questionnaire asked about the acceptance of crime surveillance technologies at different locations. First, the participants were asked to evaluate to what extend they would accept technologies like standard cameras, microphones, cameras with face recognition and location determination in their private living environment. Then, participants had to do the same in the case of a public environment. Further, we asked for acceptance of surveillance cameras at different private and public locations, which also had to be evaluated on a six point Likert scale (1=strongly disagree; 6=strongly agree). The next part of the questionnaire asked about perceived benefits and barriers of crime surveillance (also 6-point Likert scale, see above). Benefits of crime surveillance were examined in seven items, which referred to safety aspects, e.g., prevention of crime, sense of safety or the felt deterrent effect for potential criminals. Barriers referred to eight items relating to privacy aspects, e.g., protection of civil rights and personal freedom, storage of recorded data or inference of being under general suspicion.

The *fifth and last part* focused on the trade-off between the need for safety, on the one hand, and the need for individual privacy, on the other hand. Participants were explicitly asked to trade-off between their individual needs for safety and privacy when considering the employment of crime surveillance technologies at different locations on a 10-point scale (1=increase of safety; 10=protection of privacy). Completing the questionnaire took about 20 minutes. Data was collected in an online survey conducted in Germany. By using the online link, all parts of Germany had been addressed, however, participants predominately originated in North-Rhine Westphalia. Overall, the questionnaire was made available for about 8-10 weeks in the beginning of 2013. In that time, there was no high impact society event (e.g. terrorist attacks) and data collection was also accomplished prior to the current flow of refugees, which are moving to European countries.

4.2 Sample

In total, 119 participants took part in the study. As

only complete questionnaires (no missing answers) could be used for further statistical analyses, 99 data sets were analysed in the end. The mean age of the participants was 37.8 (SD=15.5) with 58.6% females and 41.4 % males. Asked for having children, the majority of 65.7% answered to have no children. Demanded for the number of persons living in their household, 38.4% reported to live in pairs, 31.3% live alone, 15.2% live in a threesome, 9.1% live with four persons, 3.0% live with five persons and also 3.0% live with more than five persons in their household. Asked for their residence, 23.2% reported to live in a detached, 13.1% in a semi-detached and also 13.1% in a townhouse. The majority of 50.5% reported to live in an apartment building. The participants were also asked for their housing conditions: 45.5% reported to be the house owner and 54.5% reported to rent. Regarding their area of residence, 35.4% live in a city centre, 29.3% in outskirts, 21.2% in suburban areas and 14.1% live in rural areas. Participants volunteered to take part in the study and were not gratified for their efforts.

5 RESULTS

The general results of the study concerning crime surveillance acceptance have been published already (van Heek et al., 2015). In this paper, the influence of the user diversity factor perceived crime threat on crime surveillance acceptance is focused.

First, the results of PCT regarding day- and nighttime at various locations are described. In a second step, the impact of individual perceived crime threat on crime surveillance acceptance is presented in detail. Initially, the segmentation of two PCT groups is introduced. Afterwards the influence of PCT on crime surveillance acceptance in terms of technologies and traditional measures enhancing perceived safety is shown. Further, the results of surveillance technologies regarding different locations as well as perceived benefits and barriers of crime surveillance are presented (depending on PCT). Finally, the results of the trade-off between the needs for safety and privacy are shown for both PCT groups. Data was analysed descriptively and, with respect to the effects of user diversity, by (M)ANOVA procedures (significance level at 5%).

5.1 Perceived Crime Threat at Different Public and Private Locations

Perceived crime threat at **daytime:** In total, i.e. summed up for all locations, the PCT during daytime was rather low (M=36.3 on a scale with max = 100; SD=12.9).

The majority of private locations was perceived as only lightly threatening, e.g., own garden (M=1.3; SD=0.6) or own home (M=1.4; SD=0.8, see Figure 1). Semi-private locations were noticed as lightly threatening, e.g., *own street* (M=1.8;SD=1) or *hotel* (M=1.8;SD=0.9). Semi-public locations were observed as slightly threatening, e.g., *market* (M=2.4; SD=1.2) and *public transport* (M=2.6; SD=1.3). Public locations were perceived as more threatening, e.g., *parks* (M=2.8; SD=1.3), *train station* (M=3.0; SD=1.4) or *underground car park* (M=3.3; SD=1.6). **Night time:** In total, PCT nighttime ratings were significantly higher (M=43.4; SD=15.5) compared to daytime ratings ($F(1,97)=15.4, p<0.01$). However, the PCT at night did not vary strongly across the different locations.

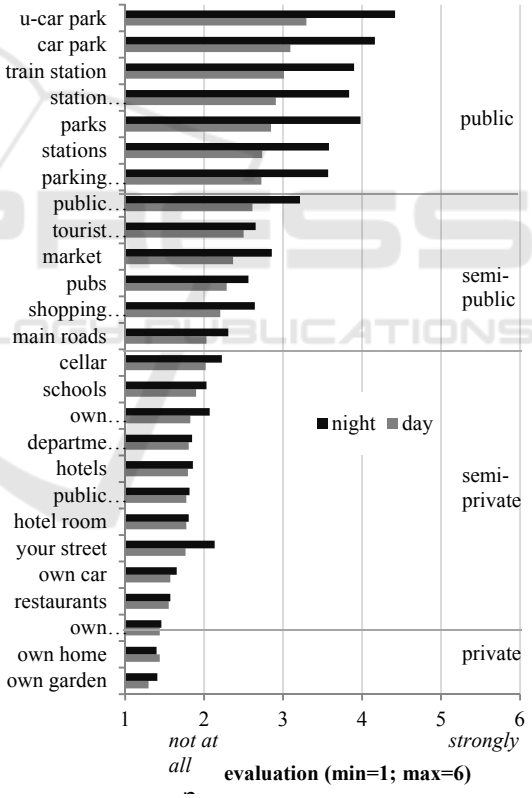

Figure 1: Perceived crime threat by day and by night.

Private and semi-private locations were not perceived differently by day or by night, except for *own street* ($M_{Night}=2.1$; SD=1.4; $M_{Day}=1.8$; SD=1.0; $F(1,98)=18.7; p<0.01$) and *own house entry* ($M_{Night}=2.1$; SD=1.5;$M_{Day}=1.8$;SD=1,1; $F(1,98)=8.7$; $p<0.01$). Concerning semi-public locations a higher

PCT was found, e.g., for *market* (M_{Night}=2.9; SD=1.4; M_{Day}=2.4; SD=1.2; F(1,98)=35.7;p<0.01) or *public transport* (M_{Night}=3.2; SD=1.6; M_{Day}=2.6; SD=1.2; F(1,98)=51.7; p<0.01) by night. Regarding public locations, nearly all locations were perceived significantly more threatening by night, e.g., *train station* (M_{Night}=3.9; SD=1.8; M_{Day}=3.0; SD=1.4; F(1,98)=102.1;p<0.01) as well as *parks* (M_{Night}=4.0; SD=1.5; M_{Day}=2.8;SD=1.2; F(1,98)=175.6; p<0.01).

5.2 Effects of Perceived Crime Threat as User Diversity Factor

So far, the acceptance of crime surveillance technologies with related benefits and barriers was reported for the whole group of respondents (van Heek et al., 2015). However, residents in urban environments are highly heterogeneous. Since we assumed that the perceived necessity and acceptance of crime surveillance technologies is affected by individual levels of crime fear, we systematically included "perceived crime threat" as group splitting variable in our analyses.

5.2.1 Segmentation of PCT Groups

Based on respondents' ratings of crime threat at different locations two groups with high and low levels of perceived crime threat (high and low PCT, cut-off=34.6 on scale with max=100) were formed by median split. Below, groups are described by socio-demographic factors. The group with high PCT consisted of a higher proportion of women than in the low PCT group (though not significant). Concerning age there was a similar distribution in groups 1 and 2 without significant differences.

Table 1: Segmentation of PCT Groups.

	Group 1 (n=50) „low PCT“	**Group 2 (n=49) „high PCT“**	p
gender	52% female 48% male	65,3% female 34,7% male	n.s.
age	M = 36.68 SD=14.42	M=38.88 SD=16.54	n.s.
familiy status	single 60% partner/married 38% divorced 2%	single 36,7% partner/married 59,2% divorced 4,1%	<.05
children status	yes 24% no 76%	yes 44,9% no 55,1%	<.05
type of residence	detached house 16% semi-detached house 14% townhouse 10% apartment building 60%	detached house 30,6% semi-detached house 12,2% townhouse 16,3% apartment building 40,8%	n.s.
place of residence	city centre 46% outskirts 22% suburban area 16% rural area 16%	city centre 24,5% outskirts 36,7% suburban area 26,5% rural area 12,2%	n.s.

Both groups differed in terms of family status and children status significantly (p<0.05). Group 1 (low PCT) consists mainly of singles (60%), while group 2 (high PCT) mainly consisted of married people or people living with a partner. Regarding children status there was a higher percentage of people with children (44,9%) in the high PCT group than in the low PCT group (24%). In terms of type and place of residence there were in parts slightly different distributions, which failed to meet significance level.

5.2.2 Fear of Crime Offenses

In a first step, we analysed to what extent people with high and low PCT differ with regard to fear of several crime offenses (see Figure 7). People with high PCT reported to feel significantly more threatened than those with low PCT (F(1,97)=48.1;p<0.01), except for the item "bicycle theft". This result pattern applied for "light" offenses, e.g. *material damage* (M_{Low}=3.0; SD=1.3; M_{High}=4.2; SD=1.2; F(1,97)=22.9; p<0.01) or *theft (in/from house)* (M_{Low}=2.6; SD=1.4; M_{High}=3.9; SD=1.3; F(1,97)=20.9; p<0.01) as well as for "serious" offenses, for example *sexual crimes* (M_{Low}=1.7; SD=1.2; M_{High}=3.4; SD=1.5; F(1,97)= 40.1;p<0.01), *offenses against life* (M_{Low}=1.5; SD=1.0; M_{High}=3.2; SD=1.5; F(1,97)=44.4; p<0.01) and *terrorism* (M_{Low}=1.3; SD=0.8; M_{High}=3.0; SD=1.4; F(1,97)= 54.5; p<0.01).

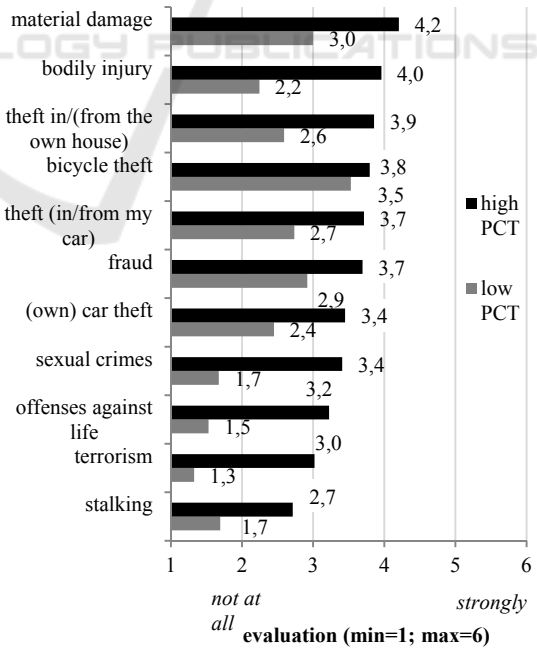

Figure 2: Fear of crime offenses for low and high PCT groups.

All PCT group differences were highly

significant. However, for serious offenses (e.g. offenses against life) the differences between fear of crime ratings for people with low and high PCT were stronger pronounced.

5.2.3 Acceptance of Crime Surveillance Technologies in Private Environments

In a next step, we examined how PCT influences the acceptance of crime surveillance technologies and traditional measures in private environments (see Figure 3). First of all, using *visible* and *invisible technologies* in private environments was both accepted by the high PCT group, while it was rather rejected by the low PCT group (*Visible:* M_{low}=3.0; SD=1.7; M_{High}=4.2, SD=1.4; F(1,98)=15.8; p<0.01; *Invisible:* M_{low}=2.7; SD=1.6; M_{High}=4.0; SD=1.3; F(1,98)=18.1; p< 0.01).

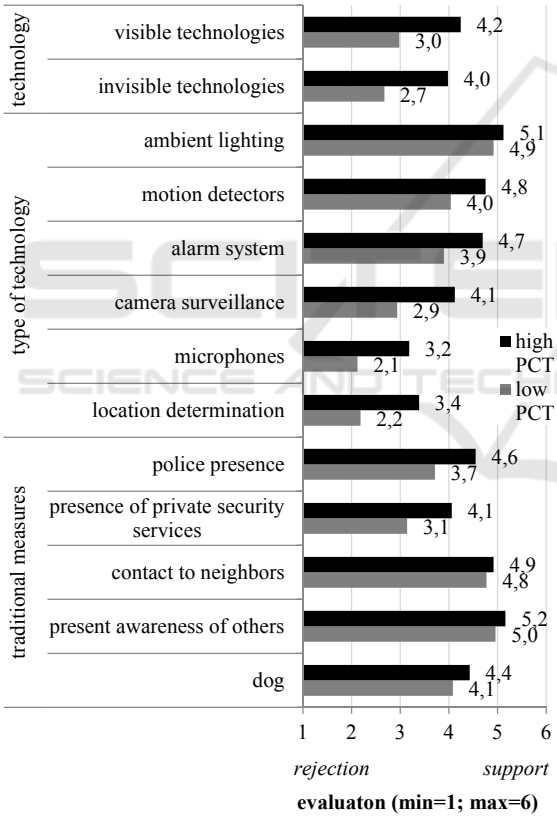

Figure 3: Acceptance of surveillance technologies and traditional measures at private environments for low and high PCT groups.

Concerning the technology type there was no difference between the PCT groups for *ambient lighting*, which was most accepted. All other types of technology were significantly more accepted by the high PCT group, e.g. *cameras* (M_{Low}=2.9; SD=1.7; M_{High}=4.1; SD=1.4; F(1,98)=13.8; p<0.01) or *location determination* (M_{Low}=2.2; SD=1.2; M_{High}=3.2; SD=1.2; F(1,98)=24.3; p<0.01). The group with low PCT even rejected the usage of cameras, microphones, and location determination.

Regarding traditional measures *more police presence* (M_{Low}=3.7; SD=1.7; M_{High}=4.6; SD=1.2; F(1,98)=7.8;p<0.01) and *more presence of private safety services* (M_{Low}=3.1; SD=1.7; M_{High}=4.1; SD=1.3; F(1,98)=8.6; p<0.01) were more accepted by the high PCT group than by the low PCT group. Both groups did not differ in their evaluations of other traditional measures like *contact to neighbours*, *present awareness of others* and a *dog*.

5.2.4 Acceptance of Crime Surveillance Technologies in Public Environments

To compare different contexts of application we also asked for the acceptance of the same crime surveillance technologies and nearly the same traditional measures in public environments (see Figure 4).

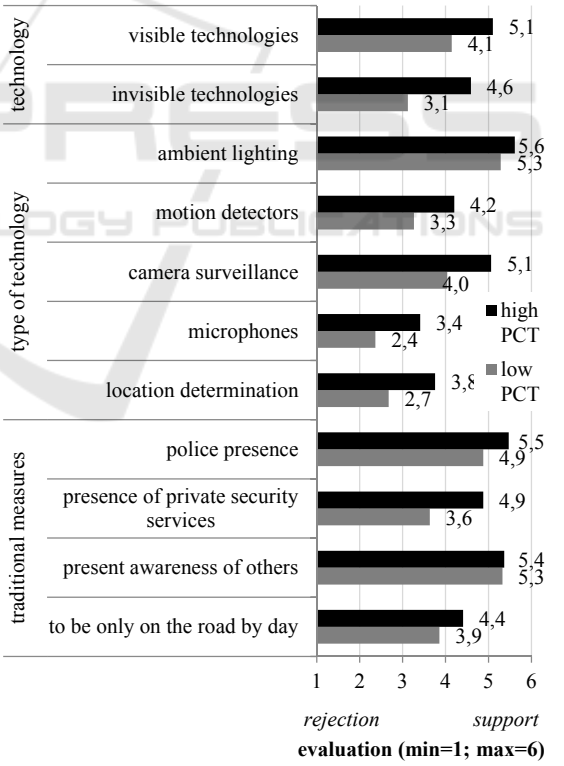

Figure 4: Acceptance of surveillance technologies and traditional measures at public environments for low and high PCT groups.

In general, use of surveillance technologies was more accepted in public (M=71.5; SD=15.4) than in

private environments (M=66.0; SD=16.0; F(1,98)= 18.4; p<0.01). First, using *visible* and *invisible technologies* in public environments was also significantly more accepted by the high PCT group than by the low PCT group (*Visible:* M_{low}=4.2; SD=1.6; M_{High}=5.1; SD=1.1; F(1,98)=11.6; p<0.01; *Invisible:* M_{low}=3.2; SD=1.8; M_{High}=4.6; SD=1.3; F(1,98)=20.8; p< 0.01).

Concerning different technology types all technologies are evaluated more positively by the high PCT group. So there is an higher acceptance of surveillance technologies by the high PCT group than by the low PCT group, for example for *cameras* (M_{low}=4.0; SD=1.5; M_{High}=5.1; SD=1.1; F(1,98)= 13.5; p<0.01) and *motion detectors* (M_{low}=3.3; SD=1.7; M_{High}=4.2; SD=1.4; F(1,98)=8.4; p<0.01).

Interestingly, the use of cameras was evaluated positively by both groups for being used in public environments. For people with low PCT *cameras* were even the only accepted crime surveillance technology. Regarding traditional measures enhancing perceived safety *more police presence* (M_{Low}=4.9; SD=1.2; M_{High}=5.5; SD=0.6; F(1,98)= 9.8; p<0.01) and *more presence of private safety services* (M_{Low}=3.6; SD=1.7; M_{High}=4.9; SD=1.1; F(1,98)=18.7; p<0.01) were more accepted by the high PCT group than by the low PCT group. Both PCT groups did not differ in their ratings of *present awareness of others* and *to be travelling by day*.

5.2.5 Perceived Benefits of Crime Surveillance Technologies

In a next step we analysed to what extent perceived benefits of crime surveillance were influenced by PCT (see Figure 5).

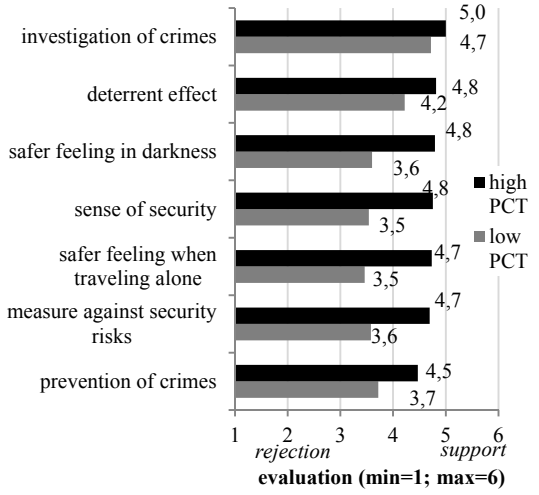

Figure 5: Perceived benefits of crime surveillance technologies for high and low PCT groups.

Nearly all benefits were significantly more accepted by the high PCT group, except *investigation of crimes,* which was most accepted, but not evaluated differently by the two PCT groups. *Deterrent effect* (M_{Low}=4.2; SD=1.6; M_{High}=4.8; SD=1.1; F(1,98)=4.5; p<0.05), *safer feeling in darkness* (M_{Low}=3.6; SD=1.7; M_{High}=4.8; SD=1.3; F(1,98)=14.7; p<0.01), *sense of safety* (M_{Low}=3.5; SD=1.5; M_{High}=4.8; SD=1.2; F(1,98)=20.0; p<0.01), *safer feeling when traveling alone* (M_{Low}=3.5; SD=1.6; M_{High}=4.7; SD=1.3; F(1,98)=18.8; p<0.01), and *measure against safety risks* (M_{Low}=3.6; SD=1.6; M_{High}=4.7; SD=1.3; F(1,98)=15.2; p<0.01) were also accepted and favoured by the high PCT group.

5.2.6 Perceived Barriers of Crime Surveillance Technologies

We also examined, how perceived barriers of crime surveillance technologies were influenced by PCT (see Figure 6).

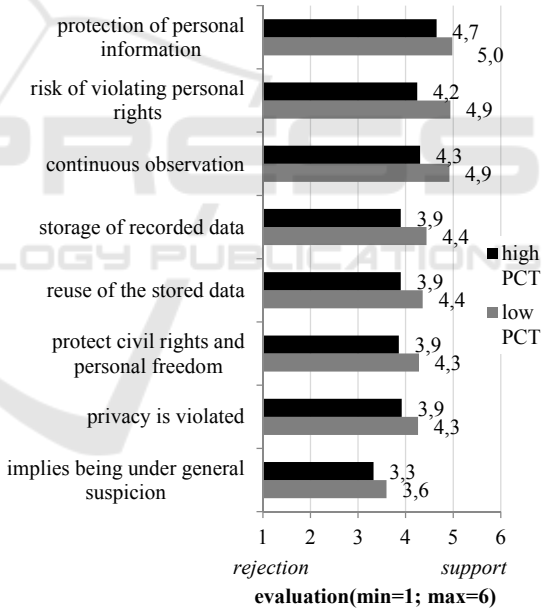

Figure 6: Perceived barriers of crime surveillance technologies for high and low PCT groups.

The highest concern for both groups was the *protection of personal information*. Interestingly, both PCT groups did not differ significantly in this concern. This also applied to the barriers *reuse of the stored data, implies being under general suspicion*, *violation of personal data* and *protecting civil rights and personal freedom*. In contrast, group differences were found for *risk of violating personal rights* (M_{Low}=4.9; SD=1.3; M_{High}=4.2; SD=1.3; F(1,98)=

6.9; p<0.01), *continuous observation* (M_{Low}=4.9; SD=1.4; M_{High}=4.3; SD=1.5; F(1,98)=4.4; p<0.05) and *storage of recorded data* (M_{Low}=4.4; SD=1.4; M_{High}=3.9; SD=1.3; F(1,98)=4.2; p<0.05). These barriers were rated higher by the low PCT group than by the high PCT group.

5.2.7 Acceptance of Crime Surveillance Technologies at Different Locations

Further, we analysed to what extent PCT influences the acceptance of crime surveillance technologies at different locations. First of all, the usage of crime surveillance technology was generally more important for people with a high PCT (see Figure 7).

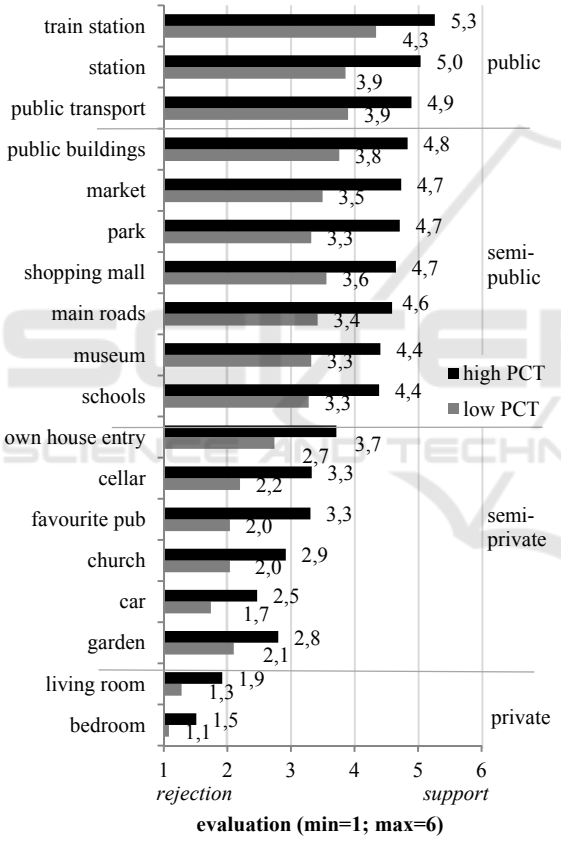

Figure 7: Influence of PCT on the acceptance of crime surveillance at different locations.

The high PCT group evaluated the usage of crime surveillance technologies significantly more positively independent of different locations. Although crime surveillance was not desired at private locations, there was a broader acceptance for it in the high PCT group, e.g. for *living room* (M_{Low}=1.3; SD=0.6; M_{High}=1.9; SD=1.3; F(1,98)= 10.0;p<0.01). At semi-private locations crime surveillance technology acceptance was also rather low, while at this point there were higher ratings of the high PCT group as well, e.g. *favourite pub* (M_{Low}=2.0; SD=1.2; M_{High}=3.3; SD=1.4; F(1,98)= 22.1; p<0.01) or *own house entry* (M_{Low}=2.7; SD=1.8; M_{High}=3.7; SD=1.6; F(1,98)=7.9; p<0.01). At semi-public locations the low PCT group rather rejected crime surveillance, while it was accepted by the high PCT group, e.g. *schools* (M_{Low}=3.3; SD=1.7;M_{High}=4.4,SD=1.5; F(1,98)=12.2; p<0.01) or *park*s (M_{Low}=3.3; SD=1.7; M_{High}=4.7; SD=1.2; F(1,98)=22.3; p<0.01). Finally, at public locations crime surveillance technologies were rather accepted by the low PCT group, while it was strongly desired by the high PCT group, e.g. *public transport* (M_{Low}=3.9; SD=1.7; M_{High}=4.9; SD=1.2; F(1,98)= 11.4; p<0.01) or *train station* (M_{Low}=4.3; SD=1.6; M_{High}=5.3; SD=1.0; F(1,98)=11.4; p<0.01).

5.2.8 Trade-off between Safety and Privacy

In a last step, we examined the effects of PCT on the trade-off between looking for safety and protecting one's own privacy (see Figure 8).

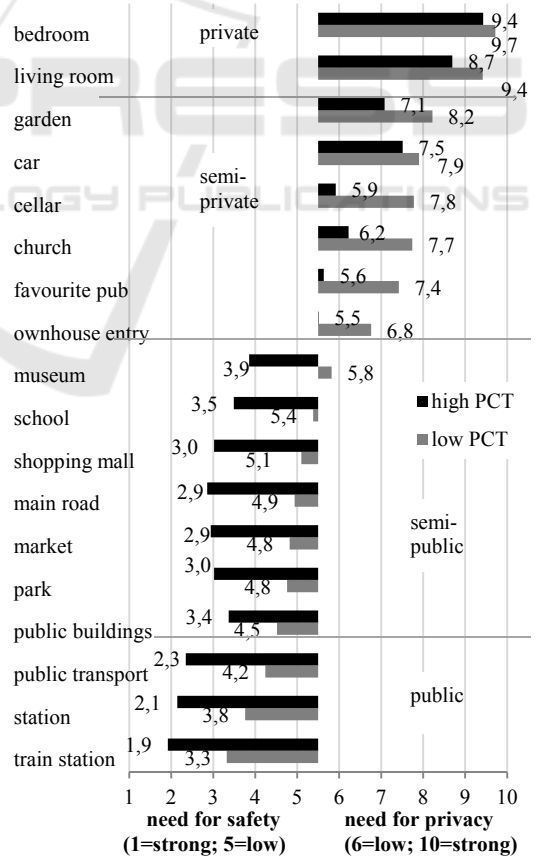

Figure 8: Influence of PCT on the trade-off between need for safety and privacy.

All in all, there were significant differences in the assessment of the relationship between safety and privacy concerning both PCT groups. Concerning *private* locations there were no differences between both PCT groups, because both groups desired to protect their own privacy at those locations. Regarding *semi-private* locations, the low PCT group had a significantly greater need for protecting own privacy than the high PCT group for nearly all semi-private locations, e.g. *cellar* (M_{Low}=7.8; SD=2.5; M_{High}=5.9; SD=3.1; F(1,98)=10.7;p<0.01), *garden* (M_{Low}=8.2; SD=2.3; M_{High}=7.1; SD=2.9; F(1,98)= 4.7; p<0.05*) or favourite pub* (M_{Low}=7.4; SD=2.4; M_{High}=5.6; SD=2.8; F(1,98)=11.8; p<0.01). At semi-public locations there were significant differences for all locations: for the low PCT group privacy was more important, while the high PCT group preferred safety, e.g. s*chools* (M_{Low}=5.4; SD=3.2; M_{High}=3.5; SD=2.6; F(1,98)=10.2; p<0.01), *main roads* (M_{Low}=4.9; SD=3.0; M_{High}=2.9; SD=2.1; F(1,98)=15.9; p<0.01). Concerning public locations, the low PCT group had a significantly stronger need for privacy, while the high PCT group strongly favoured safety, e.g. *train station* (M_{Low}=3.3; SD=2.7; M_{High}=1.9; SD=1.5; F(1,98)=10.3; p<0.01) or *public transport* (M_{Low}=4.2; SD=3.1; M_{High}=2.3; SD=1.9; F(1,98)=13.3;p<0.01).

6 DISCUSSION

This study revealed insights into acceptance patterns regarding the use of crime surveillance technologies in urban environments. In order to understand the specific needs of a diverse resident population, we examined the tolerance towards such technologies at various public and private urban locations. The results provide valuable insights for city planners regarding an acceptable employment of crime surveillance technologies at different locations in urban environments, which consider individual needs for privacy and safety.

6.1 Acceptance of City Surveillance

Surveillance technologies are accepted in those locations in which crime threat is present. Crime threat reports were higher in public spaces such as train stations or parks, especially during nighttime. Accordingly, conventional crime surveillance technologies (i.e. CCTV systems), but also conventional measures such as lighting are well accepted - as long as they are visible and installed in public spaces. Especially in urban transportation hubs such as train stations, stations or main roads, where a high number of people passes by, surveillance technologies are strongly accepted. Accordingly, a map or cartography of acceptable locations for the acceptable installation of surveillance technologies in urban environments can be derived from our findings. A completely different acceptance picture can be drawn for the acceptance of surveillance technologies in private spaces. Here, perceived crime threat is comparably low, and the use of cameras or microphones for the surveillance of private spaces is distinctly rejected. Instead, lighting and motion detectors are the only accepted measures. However, this finding does not allow jumping to the conclusion that surveillance technologies in private space are rejected in general. Combined with different functionalities than crime-stopping functions, surveillance technologies already have entered private spaces, e.g. webcams for medical monitoring or "nanny- or mummy-cams" (Kientz et al., 2007). Moreover, the context-specificity of technology-acceptance was already shown for wireless technologies either used for ICT- or for medical monitoring purposes (Himmel et al., 2013). Future studies will have to investigate in more detail the effects of usage context and "monitoring target" (myself or others) on the acceptance of surveillance technologies.

6.2 Influential Factors on Crime Surveillance Technology Acceptance

The assessment of individual privacy and safety needs provides an explanation for the identified acceptance patterns. In public spaces, people have a higher need for safety, i.e. they "sacrifice" their privacy rights for a higher safety from potential crime assaults. In turn, in private spaces, where perceived safety is higher, the need for privacy is dominating. However, in the present study, surveillance technology was operationalized as "presence of a camera", without giving information about further processing or usage purposes of recorded data. We assume, that this operationalization is ecologically valid, since people usually do not know, which of their actions are monitored and how or for what purpose surveillance data is further processed and used (Patton, 2000). Accordingly, we doubt that people are fully aware of potential privacy violations, which might occur during the following data processing stages. A next step of our research agenda is, to investigate the effects of information about potential privacy

violations of subsequent processing stages on privacy perceptions and behaviour. Research on privacy issues and user behaviour in social networks showed, that people – although claiming to be aware of their privacy rights – show a completely different behaviour pattern, i.e. exposing huge amounts of personal information (Debatin et al., 2009). Looking at perceived barriers and benefits of crime surveillance technologies, which might serve as explanatory variables for acceptance, we were rather surprised by the result pattern. Almost all benefit items received comparable levels of affirmation, which might be explained by a biased response behaviour or by an insufficient item design. For barrier-items we found a slightly more differentiated result pattern. The barrier "being under general suspicion" received the lowest affirmation in our study. This is especially noteworthy, since the issue of "general suspicion" is a widely used counter-argument in research literature ethical implications of surveillance technologies (e.g., Marx, 1998), but is apparently not reflected in individual perceptions. This result further indicates, that the ethical-normative approach of technology acceptance research needs to be complemented by a "user-focused" perspective to derive implications and design guidelines which meet public acceptance.

6.3 Effects of Perceived Crime Threat

User diversity in terms of different crime threat levels is a crucial factor in the context of crime surveillance acceptance. The contrast of people with high and low crime fears shows – not surprisingly – that crime surveillance measures and their related benefits are more accepted by people with higher fear levels. Interestingly, the two groups with high and low crime fears did not differ in their age or gender. There is not a hypothetically typical distribution with mainly women and older people who feel more threatened by crime than men and younger people. The distribution of segmented PCT groups indicates that nearly each city dweller could be part of the group with a high PCT and that perceived PCT should be the starting point for the development of urban surveillance concepts. Overall, the predominantly technology-centered planning of infrastructural city concepts, without integrating citizens into the decision-making processes, seems not sufficient to cover persons' attitudes regarding safety and privacy concerns in the context of smart cities.

6.4 Limitations and Future Research

Our empirical research approach was provided valuable insights into the acceptance of crime surveillance technologies. Some methodological issues should be taken into account, though.

First, some aspects have to be criticized in terms of content. The very similar evaluation of perceived benefits of crime surveillance showed that the item content might have been too similar. For further studies it would be desirable to use more specific and tangible items concerning perceived safety aspects, e.g. a quantifiable potential decrease in criminality rates. The same applies for perceived barriers of crime surveillance: participant's feedback showed that the queried items could be more differentiated. In further studies more specifications regarding privacy aspects will be examined (different handling of recorded data, storage issues or even face recognition). Concerning crime surveillance technologies this study focuses on the distinction between visible and invisible technologies. Future studies should differentiate between specific visible and invisible technology types. Another note refers to the classification of locations. Here, we assumed the classifications that were made by the participants of previous focus groups. The distinction between public and private locations is comprehensive and uncontroversial, whereas the difference between semi-public and semi-private locations is rather small. Therefore, in further studies a more precise definition of location categories is necessary. Besides terms of content, for further studies other methodological approaches should be applied. Since four relevant attributes (location types, safety aspects, privacy aspects and technology type) were identified in this study, the implementation of a conjoint analysis could be useful to gain a deeper insight into the acceptance of crime surveillance. This way, the relative importance of different attributes could be determined and the trade-off between safety and privacy could be characterized precisely.

Also, some aspects concerning the sample could be improved and continued in further studies: first, the sample size of this study was rather small, so the findings should be replicated in larger and more representative samples, which contain a higher number of men and a higher number of older persons. To involve place of residence as a hypothetically influencing variable, further samples have to contain a higher number of people living in rural areas. Finally, as this study only focuses German city dwellers, our approach and findings

could be replicated in other countries to compare crime surveillance needs and desires of city dwellers of different countries and cultures.

A similar remark is directed to the flow of refugees and emigrants from Arabic countries into all parts of Europe. Under these conditions, where so different cultural values and norms regarding intimacy, protection needs as well as personal nearness and distance meet if not clash, perceptions of security might be different. Therefore, future studies should replicate the findings.

A final note regards the development of communal or political policies. Even though the findings here do not allow the formulation of concrete recommendations for the use of surveillance technologies, still, the findings could be integrated in the education of communal workers which need to know both sides of the coin: security for the individual and the commune as such but also the respect of keeping privacy of the individual and the commune.

REFERENCES

Arning, K., Ziefle, M. and Mühlhans, H., 2013a. Join the ride! User requirements and interface design guidelines for a commuter carpooling platform. In Marcus, A. [ed.], *Design, User Experience, and Usability,* Berlin Springer, pp. 10-19.

Arning, K., Kowalewski, S., and Ziefle, M., 2013b. Modelling User Acceptance of Wireless Medical Technologies. *Wireless Mobile Communication and Healthcare*, 61, pp. 146–153.

Alsnih, R. and Hensher, D. A., 2003. The mobility and accessibility expectations of seniors in an aging population. Transportation Research Part A. *Policy and Practice*, 37(10), pp. 903–916.

Baumer, T. L., 1978. Research on fear of crime in the United States. *Victimology*, 3, pp. 254–264.

Blöbaum, A. and Hunecke, M., 2005. Perceived Danger in Urban Public Space The Impacts of Physical Features and Personal Factors. Environment and Behavior, 37(4), pp. 465–486.

Chattopadhyayr, D., Dasgupta, R., Banerjee, E, R. and Chakraborty, A., 2013. Event Driven Video Surveillance System using City Cloud. *Proceedings of the first International Conference on Intelligent Infrastructure at the 47th Annual National Convention Computer Society of India.*

Covington, J. and Taylor, R. B., 1991. Fear of Crime in Urban Residential Neighborhoods. *Sociological Quarterly,* 32 (2), pp. 231–49.

Debatin, B., Lovejoy, J. P., Horn, A.-K., and Hughes, B. N., 2009. Facebook and Online Privacy: Attitudes, Behaviours, and Unintended Consequences. *Journal of Computer-Mediated Communication*,15(1),pp.83–108.

Dickerson, A. E., Molnar, L. J., Eby, D. W., Adler G., Bédard, M., Berg-Weger, M., and Trujillo, L., 2007. Transportation and Aging: A Research Agenda for Advancing Safe Mobility. *The Gerontologist,* 47(5), pp. 578–590.

Gumpert, G. and Drucker, S. J., 2001. Public boundaries: Privacy and surveillance in a technological world. *Communication Quarterly*, 49(2), pp. 115–129.

Himmel, S., Ziefle, M. and Arning, K., 2013. From Living Space to Urban Quarter: Acceptance of ICT Monitoring Solutions in an Ageing Society. In Kuroso, M. (Ed.) *Human-Computer Interaction. Users and Contexts of Use*, Berlin Springer, pp. 49-58.

Isnard, A., 2001. Can surveillance cameras be successful in preventing crime and controlling anti-social behaviours. *Proceedings of the character, impact and prevention of crime in regional Australia Conference*, Townsville, 2.-3.8.2001.

Kientz, J. A., Arriaga, R. I., Chetty, M., Hayes, G. R., Richardson, J., Patel, S.N., and Abowd, G.D., 2007. Grow and Know: Understanding Record-keeping Needs for Tracking the Development of Young Children. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, San José, CA, 30.4. - 3.5.2007, NY, USA, ACM, pp. 1351–1360.

La Vigne, N. G., Lowry, S. S., Markman, J. A., and Dwyer, A. M., 2011. *Evaluating the Use of Public Surveillance Cameras for Crime Control and Prevention.* Final Technical Report. Washington, DC, The Urban Institute.

Lewis, D. A. and Maxfield, M. G., 1980. Fear in the Neighborhoods: an Investigation of the Impact of Crime. *Journal of Research in Crime and Delinquency*, 17(2), pp. 160–189.

Loewen, L. J., Steel, G. D., and Suedfeld, P., 1993. Perceived safety from crime in the urban environment. *Journal of environmental psychology*,13(4), pp. 323-331.

Marshall, R. D., Bryant, R. A., Amsel, L., Suh, E. J., Cook, J.M. and Neria, Y., 2007. The psychology of ongoing threat: relative risk appraisal, the September 11 attacks, and terrorism-related fears. *American Psychologist*, 62(4), p. 304.

Marx, G. T., 1998. Ethics for the new surveillance. *The Information Society,* 14(3), pp. 171–185.

Patton, J. W., 2000. Protecting privacy in public? Surveillance technologies and the value of public places. *Ethics and Information Technology*, 2(3), pp.181–187.

Plouffe, L., and Kalache, A, 2010. Towards Global Age-Friendly Cities: Determining Urban Features that Promote Active Aging. *Journal of Urban Health*, 87(5), pp. 733–739.

Scarborough, B. K., Like-Haislip, T. Z., Novak, K. J., Lucas, W. L., and Alarid, L. F., 2010. Assessing the relationship between individual characteristics, neighborhood context, and fear of crime. *Journal of Criminal Justice*, 38(4), pp. 819–826.

Sheldon, B., 2011. Camera surveillance within the UK: Enhancing public safety or a social threat?

International Review of Law, Computers & Technology, 25(3), pp. 193–203.

Smith, M. J. and Clarke, R. V., 2000. Crime and public transport. *Crime & Justice*, 27, pp. 169-233.

Song, M., Tao, D., and Maybank, S.J., 2013. Sparse Camera Network for Visual Surveillance – A Comprehensive Survey. *Cornell University.*

Van Heek, J., Arning, K., and Ziefle, M., 2015. Safety and privacy perceptions in public spaces: An empirical study on user requirements for city mobility. In Giaffreda, R., Caganova, D., Li, Y., Riggio, R., and Voisard, A. (Eds.). *Internet of Things 2014*, LNICST 151, Springer Berlin Heidelberg.

Whitaker, R., 1999. *The end of privacy: How total surveillance is becoming a reality.* Ney York, NY, The New Press.

Wiecek, C. and Saetnan, A.R., 2002. Restrictive? Permissive? The Contradictory Framing of Video Survei-llance in Norway and Denmark, *Norwegian University of Science and Technology,* Working Paper 4.

Ziefle, M., Schneider, C., Valeé, D., Schnettler, A., Krempels K.-H. and Jarke, M., 2014. *Urban Future outline (UFO) A roadmap on research for livable cities*. ERCIM News (N. 98): http://ercim-news.ercim.eu/en 98/keynote-smart-cities.

Ziefle, M., and Wilkowska, W., 2015. *What makes people change their preferences in public transportation – opinions in different user groups.* In Giaffreda, R., Caganova, D., Li, Y., Riggio, R., Voisard, A. (Eds.). Internet of Things 2014, LNICST 151, Springer Berlin Heidelberg, pp. 137-144.