Mapping Emotions: Spatial Distribution of Safety Perception in the City of Olomouc

Jiří Pánek, Vít Pászto and Lukáš Marek

Abstract Places are strongly linked with emotions and can be considered safe or unsafe, pleasant or ugly, favourite or boring among other emotions. Subjective perceptions of a city can be valuable sources of information for city planners and a local administration. Among the above-mentioned emotions that have an effect on the quality of life for people in a city, the perception of safety has a prominent position. Safety and fear of criminality affect our interaction with public spaces the most. But criminality does not have to be the only reason people feel uncomfortable in a city, they may also be afraid of the darkness or the friendlessness of a place. The paper describes the mapping of unsafe places in the city of Olomouc via a paper-based questionnaire and a web-based crowdsourcing tool PocitoveMapy.cz. In total, the authors collected answers from 661 respondents; 144 used the online tool and 517 used the paper-based version. The final dataset comprises 1516 places (453 online/1063 questionnaire). The data were gathered over the period between 1st October and 2nd December 2015. The authors collected data that are gender specific as well and time of day specific, therefore it was possible to analyse the differences between daytime and night-time fearful places in the city as well as places that are perceived unsafe by women and men. The spatial density analysis, local correlations and hexagonal aggregation revealed hot-spots that are felt by the citizens of Olomouc to be unsafe. The strongest agreement in votes can mainly be found in the three localities with the densest localisation of votes. In these localities,

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a strong correlation exists also between the perception of fear during the daytime and the night-time. The results of the case study can be used by the local police department or administration authorities in the future development of safety strategies for the city.

Keywords Emotional mapping · Subjective data · Unsafe places · Olomouc · Spatial correlation · Geovisualisation

1 Introduction

Personal security plays an important role in the quality of life and well-being of citizens. Perceived safety and fear of crime have an influence on people's behaviour (Curtis 2012). Participatory mapping and qualitative GIS (sometimes also called GeoParticipation) allow city planners and decision makers to deploy new tools and methods to collect both qualitative and quantitative data about cities, their dynamics and the people living there (Kloeckl et al. 2011). Most geospatial applications rely on objective data only, although there can be discussion concerning the extent to which GIS data are objective, as there is always a level of generalisation, uncertainty and author's bias (Pickles 1995). The call for a more humanised and participatory approach to geospatial information and technologies has been heard since the publication of the *Ground Truth* (Pickles 1995).

The authors collected and analysed subjective data linked to perceived safety in the day-time and in the night-time in the city of Olomouc, Czech Republic. The data were collected in the form of an emotional map and the outcomes can be seen as a version of a Gould-style mental map (Gould 1986). Emotions and space are connected because every location can evoke an emotion (Mody et al. 2009) and places can be felt to be attractive, boring, dangerous or scary, among other emotions (Korpela 2002). In the past 10 years several projects have dealt with georeferenced emotions and the methods used to gather emotional data can be divided into three groups: (1) biometric measurements (Bergner et al. 2011; Nold 2009), (2) extraction from user generated content such as Twitter, Flickr, Facebook, etc. (Biever 2010; Bollen et al. 2011; Mislove et al. 2010), and (3) surveys (Huang et al. 2014; MacKerron and Mourato 2010; Mody et al. 2009). The author's approach can be considered to be a survey.

Griffin and Mcquoid (2012) distinguished between three categories when talking about maps and emotions. These categories are (1) maps of emotions, (2) using maps to collect emotional data, and (3) emotions while using maps. The case study described in this paper is a combination of the first two categories. Maps were used to collect the emotional information, and also to visualise the emotional data.

Emotions are one of the defining characteristics of every human being and yet their presence in maps and spatial data is uncommon (Griffin and Mcquoid 2012). Several authors (Barrett 2006; Reeve 2014; Russell 1980) described emotions as a two-dimensional structure with the axis being pleasant-unpleasant and high-arousal or low-arousal. Geographers, on the other hand, described emotions as subjective relational flows between places and people (Smith et al. 2012) and therefore their definition is not consistent with a two dimensional understanding of emotions.

The analysis between crime and place started with the *Chicago School*, and later in the 1980s when the "new" Chicago School implemented GIS into the ecological studies of crime patterns and theories of environmental criminology (Anselin et al. 2000). Studies proved that perceptions of safety in an urban environment are influenced by environmental characteristics; mainly by what is visible (Fisher and May 2009; Lipscomb 2014). Although historically cartography was mainly focused on treating that which is visible or can be mapped (including air temperature and wind speed) (Wilson 2011), critical and feminist cartographers always advocated mapping a space as people experience it, with emotions included (Pearce 2008). Hauthal and Burghardt (2014) argued that *…mappers of georeferenced emotions are almost exclusively researchers…* using emotional maps in various fields such as tourism (Mody et al. 2009), navigation (Gartner 2012; Huang et al. 2014) and city planning (Raslan et al. 2014).

Mapping of safety and fear of criminality has become a modern trend in various fields such as cartography, GIScience, environmental ecology, behavioural geography, urban planning and psychology. In the Czech/Slovak context only a few authors dealt with the mapping of safety (Jíchová and Temelová 2012; Sessar and Sirotek 2001; Stasíková 2011), and none of them used emotional or mental maps to collect or visualise the data. Němečková (2014) used subjective data to analyse safety in the city, but the spatial element of the data was not even explored in her research. Some researchers (Brown and Polk 1996; Clemente and Kleiman 1977; Oc and Tiesdell 1997) argued that fear of criminality could be as dangerous as criminality itself, therefore the application of GIScience became trendy in analysing spatial patterns of criminality and how it affects people´s behaviour within an urban environment (Chainey and Ratcliffe 2013; Doran and Burgess 2011; Leitner 2013; Santos 2012).

The aim of the paper is to analyse subjective data about the perception of safety in the city of Olomouc. The authors are looking for patterns and hot-spots within the city and if there are any relevant linkages between gender and visibility (day-time vs. night-time) and the spatial distribution of places marked as unsafe. The uniqueness of the presented case-study is its combination of online-crowdsourced data and information collected on the street through paper-based questionnaires.

2 Background

2.1 Location of the Case-Study

Olomouc is a historical city in the Czech Republic with a population of 99.809 (Czech Statistical Office 2015), it is also the seat of The Regional Authority of the Olomouc Region and the sixth largest city in the country. The city is sometimes called the "city of parks" due to the several parks that surround the historical city-centre. The parks, although perceived as a pride of the city, are often a source of danger and criminality, mainly in the evenings and nights. The perception of safety in the city and its temporal variability (day/night) as well as spatial distribution was the main concern of the authors. The Olomouc Region stated, in its Strategy of Criminality Prevention 2013–2016 (Olomouc Region 2015) that one of its four visions is to increase the sense of safety in the region. Based on this document the authors believe that, in the area of criminal prevention, emotional mapping and citizens perception of safety is in alignment with the long-term strategy of the region.

Emotional maps are often a neglected part of cartography, yet they contain relevant information, especially for town and regional planning. There has been limited research into emotional maps within the Czech Republic and almost no practical implementation of such maps within local government administrations. A few examples of research in the area of safety perception were mentioned in the introduction section. Nevertheless, the authors acknowledge that this field deserves much more attention that it has been given up to now.

2.2 Data

The collection of data was managed in two separate ways: an analog, paper-based questionnaire and a crowdsourcing web-based application. All paper-based questionnaires were later digitised into a GIS environment (specifically ArcGIS for Desktop 10.3). A total of 661 respondents completed the questionnaire; 144 used the online tool and 517 used the paper-based version. The final dataset comprises of 1516 places (453 via online tool and 1063 via questionnaire). The data were gathered in the period between 1st October and 2nd December 2015.

Both the analog as well the digital collection procedure had two main questions for the responders:

(a) mark places where you feel unsafe in Olomouc at night (when it is dark),
(b) mark places where you feel unsafe in Olomouc during the day (when there is a light).

For the analog collection of data, trained interviewers (students of geoinformatics at Palacký University Olomouc) approached each respondent at random with

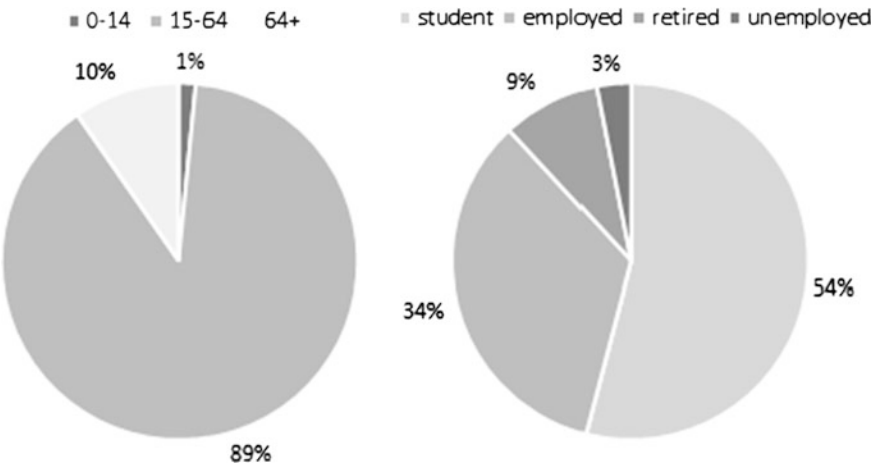

Fig. 1 Paper-based questionnaire respondents (from *left* age groups, occupation status)

the main task being to establish contact with him/her and to convince them to participate in the case study. In total, 236 men (46 %) and 281 women (54 %) participated in the survey. Other basic characteristics about the participants are shown in Fig. 1. The questionnaire items (excluding the main questions above) were as follows:

- gender,
- age group,
- occupation status,
- place of residence (aggregated to city districts),
- frequency of visits in marked unsafe places (Fig. 2),
- date and place of the interview,
- reasons for feeling unsafe (optional).

The second option for collecting the data, as opposed to classical paper-based questionnaires, was crowdsourcing. The authors used their own tool PocitoveMapy.cz to collect the emotional data. Since the main research aim was to identify places associated with unsafe feelings, some of the above mentioned items were omitted from the online tool. The tool itself is designed as a web-application based on Leaflet Library. Similar to other web-based tools for crowdsourced mapping, it allows users to collect spatial data on a slippery map background. Unlike Ushahidi, Umap, ArcGIS Online and many others, PocitoveMapy.cz does not require the registration or installation of any specific software, plug-in or virtual server. The simplicity of the tool helps to engage various target groups, while it is still rich in information gathered. The tool has been used previously in mapping bikers safety in Reykjavík (Iceland), in mapping links between environment and public health in the Czech Republic and for neighbourhood development activities in small town in Bohemia.

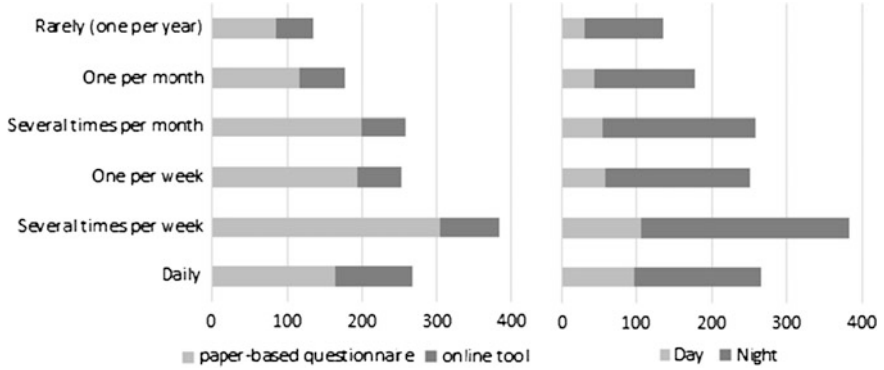

Fig. 2 Frequency of attendance in the places marked as unsafe by the acquisition method (*left*) and by time of day (*right*)

3 Methods

The original data consist of points, which express people's perceptions of fear in individual places. As the data points were dense in some locations they were aggregated into a hexagonal grid with a cell area of 1 ha (Burian et al. 2014). Firstly, the basic GIS tools were used (e.g. frequency analysis, spatial joining, density analysis) for the purpose of visual analytics and data interpretation. The resulting unsafe places were displayed on maps according to various attributes, in order to reveal their spatial patterns and distribution. To emphasize certain localities with a high point density, i.e. places multiply marked as unsafe, density analysis was performed. The significance of such localities was evaluated using 18 neighbouring cells (two-layer hexagons around each particular cell), which allowed highlighting of the most unsafe ones.

Secondly, aggregated grids were entered into the evaluation by the local Spearman's ρ. The neighbourhood of individual grid cells was defined as 1 % of all grid cells, i.e. each hexagon is connected to approximately 100 of the nearest hexagons.

The computation of the correlation coefficient is the most common method to explore and enumerate the association between two (or more) characteristics. However, correlation does not determine the mutual causality of the investigated factors. Pearson's correlation, Spearman's rank correlation and Kendall's rank correlation are widely used methods for the correlation calculation (Reimann et al. 2008). The correlation per se usually provides a global overview of the described association, which may appear to be an inconvenient method in the case of local studies.

Non-parametric Spearman's rank correlation (Spearman's ρ) was undertaken to analyse the associations between people's cognition of fear/lack of safety in the urban environment. Spearman's correlation can explore the non-linear relations of

characteristics, and this was the main reason for using it, because the character of the analysed data does not allow us to ensure normal probability distribution. Measured values are substituted for their rank in the calculation of Spearman's correlation.

$$\rho = 1 - \frac{6\sum_{i=1}^{n}(p_i - q_i)^2}{n(n^2 - 1)}$$

Non-parametric Spearman's rank correlation, described above, where the expression ($p_i - q_i$) means differences in the rank of values corresponding to the measured characteristics and n is a number of pairs. In the study, the authors applied the local version of Spearman's ρ, which calculated the correlation between observations neighbouring in geographical space. The local Spearman's ρ was computed using the R language, utilizing the adapted function based on the package lctools (Kalogirou 2011, 2015).

4 Results

Aggregated grids were entered into the evaluation through the local Spearman's ρ. The neighbourhood of individual grid cells was defined as 1 % of all grid cells, i.e. each hexagon is connected to approximately 100 of the nearest hexagons.

The visualization of marked unsafe places together with density analysis surface is depicted in Fig. 3. The most unsafe places are located at the main train station (eastern part of the city), around the city centre (mainly in surrounding parks and small streets), at localities in suburban residential areas (southern and south-eastern parts of the city) and at places with underpasses.

A similar pattern can be identified from the map in Fig. 4, which uses hexagons with an aggregated points count. It is possible to detect unsafe localities more precisely than using density surface and it is still easier to recognise spatial patterns in comparison with individual points visualization.

The following maps (Fig. 5) display the distribution and count of unsafe places according to the time of day. Respondents tended to mark places connected with fearful emotions during the night (or darkness; 1109 records) approximately three-times more than during the day (407 records). On the one hand this is obvious but on the other hand it means there are still localities demanding higher personal security attention during the daylight. These are, again—the main train station, parks (especially Bezručovy Sady), underpasses and residential areas which are partly treated as socially excluded localities (Nový Svět, Černá cesta). In optional commentaries respondents' argued that these are places with "weird people, the homeless, pickpockets, paupers, drunk people, molestation, heavy traffic, underpasses and Roma people" among other comments.

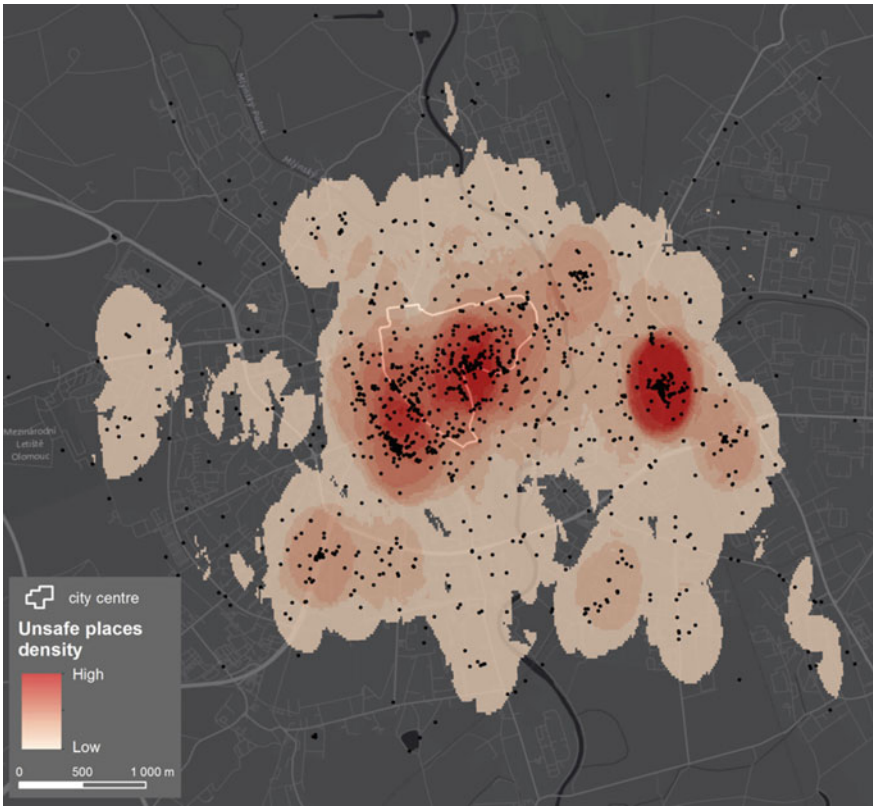

Fig. 3 Distribution of unsafe places (*black dots*) and their density rate

Additionally, unsafe places (marked at least once) cover almost all of the city centre during the night (or periods of darkness). Also localities within large blocks of flats in suburban residential areas are highlighted as unsafe during the night and in darkness. The main reasons respondents feel unsafe are "not enough street lights, dark streets, the homeless, drunk people, bad feelings, drug users, weird people, underpass, weird people".

The main difference between men's and women's unsafe marked places is that men are not as afraid in the city centre as women (Fig. 6). Also parks and underpasses are localities in which men feel less frightened. On the other hand, women did not mark the above-mentioned socially excluded localities as unsafe very often (it is maybe because they rarely visit those localities—according to the questionnaires), whereas men visited them more often. Nevertheless, there were also comments about positive aspects of the city, stating that Olomouc is perceived as much safer than other cities of a comparable size in the Czech Republic.

The visualisation of Spearman's ρ for all pairs of feelings is depicted in Fig. 7. Only positive associations were found between people's evaluations of places, as

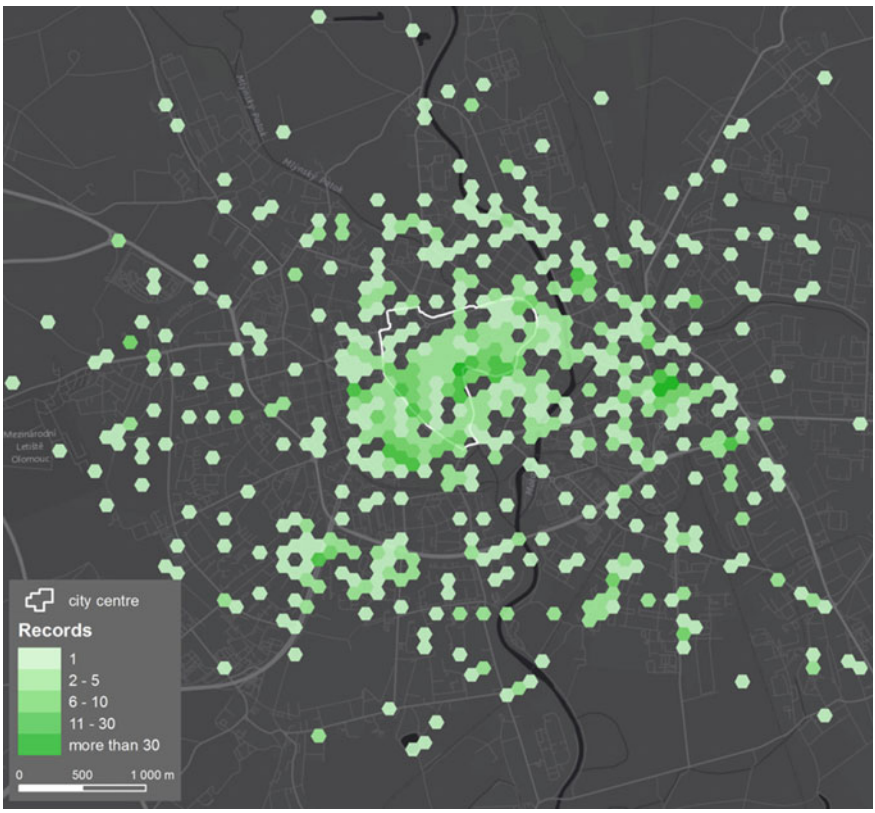

Fig. 4 Distribution of all unsafe places marked by respondents

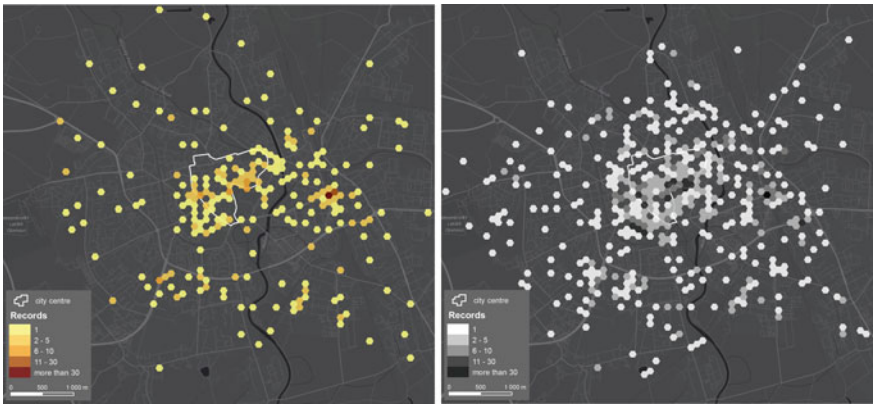

Fig. 5 Distribution of unsafe places by time of day (day on *left*, night on *right*)

Fig. 6 Distribution of unsafe places by gender (women on *left*, men on *right*). *Note* data from web tool is not included due to technical issues

shown in red. It is important to note that positive associations not only occur among places people voted for more often in both topics (represented by more records), but also among places that were mentioned only rarely. Meaning that correlations express the (local) topical agreement among places. The correlation also depicts a mutual/two-sided relationship. The lighter colour of the area, the weaker associations between feelings exist in the area. Contrarily, the darker the colour of the place, the stronger association is present in the neighbourhood. The areas with the value of the correlation around zero present the places where the associations among characteristics are weak. Individual points (votes) are shown in Fig. 7 in order to provide a more complex overview of the evaluated situation in the results. The information about the frequency of fearful feelings in individual places is depicted by the size of points in Fig. 7.

According to local Spearman's correlation, the strongest association between men's and women's perception of fear and safety can be found in the periphery of the city, and this is caused by the sparse number of votes in these places. The strongest agreements in votes can mainly be found in the three localities (corresponding with previous findings) with the densest localisation of votes; (A) the main train station, (B) city parks, and (C) the old town near the church of St. Michael. In these localities, a strong correlation exists also between the perception of fear during the day and during the night. Moreover, other places were identified as places to be fearful of during the daytime and the night-time—(D) neighbourhood Černá cesta and (E) tř. Svobody.

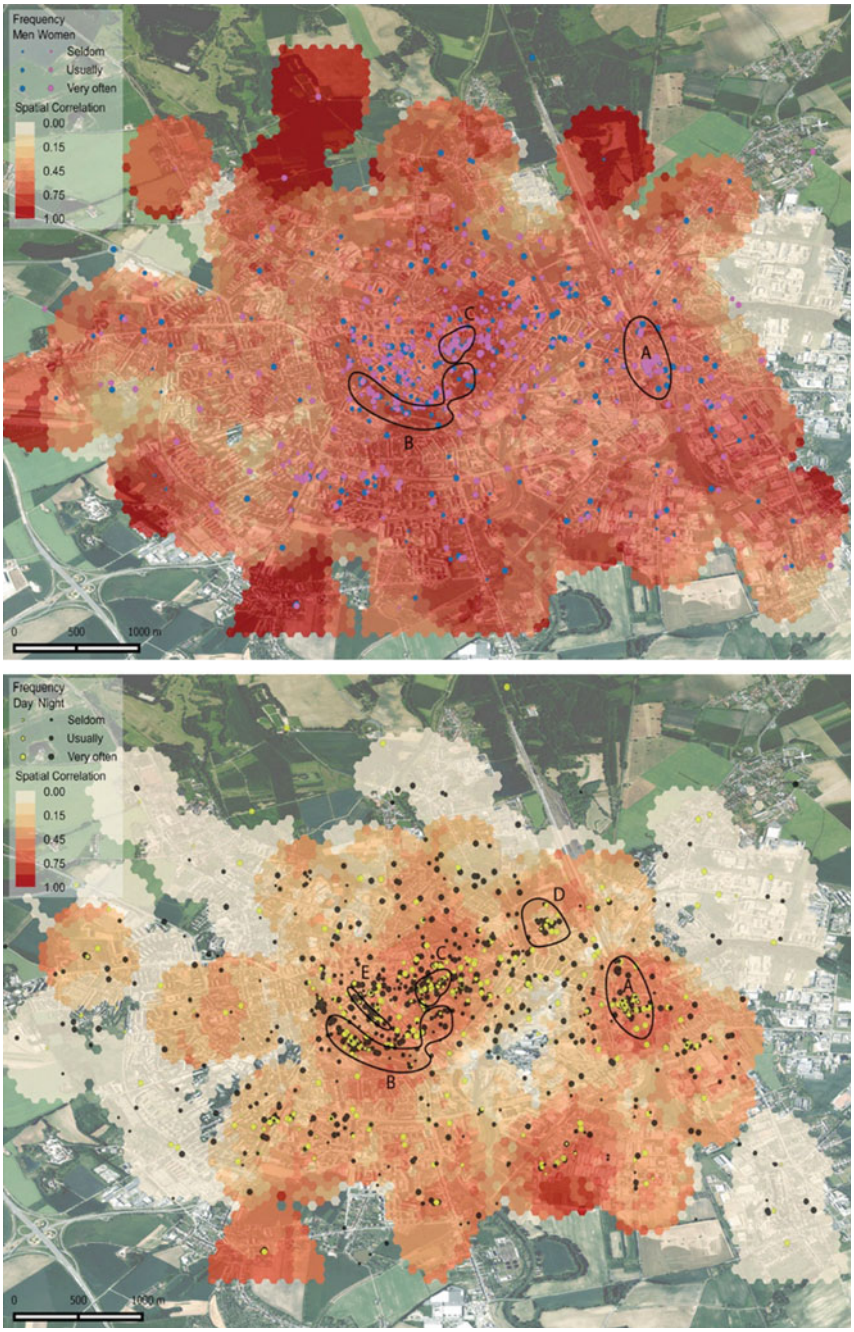

Fig. 7 Spatial Spearman's correlations between men's and women's cognition of fearful places (*top*); and correlations between citizens' perception of fear during the day and during the night (*bottom*)

5 Discussion and Conclusions

Emotional mapping plays an important role in the processes of community planning, participatory development and the creation of knowledge about common spaces and the environment. Emotional maps allow users to get involved in the process of collecting information related to their emotional links with their environment. The idea is grounded in the GeoParticipation approach—using spatial tools in order to involve citizens in community participation and decision-making processes related to public spaces. The outcome of this case-study combines data from analog paper-based, traditional and top-down questionnaires with data collected by digital crowdsourcing and the participatory web-application PocitoveMapy.cz.

The authors analysed the spatial distribution of locations marked as unsafe in Olomouc by gender groups of respondents (women/men), as well as by time of day respondents feeling unsafe in a specific location (daytime/night-time). There were locations that show spatial correlation among these categories. There were also locations that created spatial hot-spots of unsafety. The weakest point in the local correlation analysis is the evaluation of places where votes are seldom placed. The detached places might influence the visual interpretation of spatial associations. Therefore, the visualisation of the results of the analysis and the original votes is suitable, in order to provide a complex overview of the phenomenon. Using quantitative methods for the evaluation of people's sense of the city may help to identify places that should be of interest to local governments and city councils in order to help them manage public spaces in an effective way.

The future outlook of the research can include spatial analysis based on the different age groups of respondents, or based on their relationship with the city. Citizens who live in the city may have different perceptions of the unsafe places to citizens who only commute to Olomouc due to work or study issues. Nevertheless, the first analysis proved that the inclusion of qualitative and subjective data can produce relevant spatial as well as temporal data, which can be used in local planning and community development. The combination of subjective layer with "official" data, for example from the police department, can enhance the information richness of the dataset and reveal new relationships among various datasets.

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