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Article

GIS-Based Statistical Analysis of Detecting Fear of Crime with Digital Sketch Maps: A Hungarian Multicity Study

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Abstract: This study evaluates fear of crime perception and official crime statistics in a spatial context, by applying digital sketch maps and statistical GIS methods. The study aims to determine explanatory motives of fear of crime by comparing results of selected large, medium and small sized Hungarian cities. Fear of crime information of residents were collected by using a web application, which gave the possibility to mark regions on a map, where respondents have a sense of safety or feel fear. These digital sketch maps were processed by GIS tools, and were converted to grid data, in order to calculate comparable explanatory variables for fear of crime analysis. The grid-based normalised model reflected some similarities and differences between the observed cities. According to the outcomes, examples were found both in coincidences and opposite correlations of crime statistics and perception of unsafe places, highlighting the importance of locality in fear of crime research. Additionally, the results mirrored that the size of the city or the respondent's sex does not significantly influence the overall judgment of places, rather the absolute number of safe markings and the local number of registered crime events could affect local results.

Keywords: fear of crime; crime mapping; digital sketch maps; mental maps; statistical GIS

1. Introduction

The necessity of researching fear of crime as a phenomenon, as it is outlined in the work of Furstenberg [1] and Zedner [2], appeared in the 1960's in Britain and in the USA as a reaction to the emergence of urban violence. Although fear of crime has become an intensively researched topic since then [3,4], there are still many debates on its thematic pillars [5]. Several attempts were made at rephrasing the meaning of fear of crime: for instance, Ferraro and LaGrange described this phenomenon as a negative emotional feeling generated by crime or related symbols [6]. Their research study intended to define whether individual properties, such as sex or age, could have an effect on fear of crime, claiming, for example, that elderly people are more afraid of things that young people are less anxious about, or compared to men, women might feel fear at different places [7,8].

According to wellbeing studies, one of the most important elements of life quality is a safe environment [9]. One might think that the sense of security is basically influenced by crime [10,11], but also geography seems to matter too. The importance of the spatial factor already appeared as an environmental indicator in the context of crime as early as 1993 [12], in addition to that, recent research outcomes support this idea [13,14]; namely, space matters in decisions of which places to avoid because of fear of crime [15].

Although numerous studies have proved that various spatial factors can trigger fear of crime, the fact is that crime rates in certain areas are not necessarily as high as expected [16,17], consequently, additional explanatory factors should be considered as well. Doran and Lees [18], for example, found relationship between fear of crime and physical disorder. Later, Doran and Burgess [3] proved that the environment in general plays an important role in fear of crime. It was recently shown that even improvements in the environment can have a positive effect on reducing fear of crime [19]. Furthermore, a large amount of studies confirmed that fears of crime are concentrated in areas, which can be described by definite environmental characteristics. For example Lederer and Leitner [20] concluded that fear of being a victim of burglary can be assigned to well-defined geographical hot spots, as well as it is connected with definite statistical features and even with areas having less technical protection.

A typical problem of mapping fear of crime, though, is the lack of data on location perceptions. In many countries police have not completed any survey on this topic, therefore, their own data surveys should be made to accumulate information from, e.g., questionnaires [21] or from digital sketch maps, which would conceivably quantify—in a specific way—the level and the area of fear of crime within a city [22–26]. Additionally, several contemporary research papers on fear of crime apply modern IT technologies to draw a more precise picture of the issue. For example Solymosi et al. [27] developed a FOCA application (fear of crime application), which investigates fear of crime as a dynamic phenomenon by tracing the participants' activities, and in this way, the avoidance of certain places. Kounadi et al. [28] on the other hand, applied geolocated Twitter data to detect population having a heightened crime risk for burglaries and robberies in Vienna. However, Twitter is not that much useful in countries—such as Hungary—where its penetration is not large enough.

Comparative studies on different cities including fear of crime and official police data are still underrepresented. There are fresh papers about comparing spatial patterns of fear of crime and recorded crime events [21,26], however their conclusions have been drawn by examples of one selected city, and did not deal with possible variances among towns, and factors of multicity differences. This study aims to go further by conducting a comparative analysis of cities to detect similarities and biases between crime event data and fear perception of local citizens. At the outset of the research, we assumed that urban patterns of fear of crime and areas of safety could have been supported by police data, though it is also possible that unsafe and safe areas do not match spatial patterns of official crime statistics, and the most crime infected areas are by no means the most scary places in the opinion of those surveyed. It is, therefore, an objective of the paper to evaluate what motives are decisive in local fear of crime and whether urban differences matter in the perception of safety or unsafety.

2. Materials and Methods

Our research applied a digital sketch map tool, which was designed in its initial form in 2016 [29]. Since then, digital sketch map data have been acquired in many cities and in various time spans of the years. The analysed dataset of this study covers the period between January 2016 and March 2019, having digital sketch maps of 910 respondents, of which 41% were women and 59% were men. Altogether the respondents have drawn 3955 polygons (obviously one could have drawn more than one feature), and almost the half of them (51%) indicated places of fear (the rest referred to the places of safety). Crime incident data, which were needed for comparative spatial analysis, were provided by the Hungarian police for the period of January 2013 to December 2018.

2.1. Data Collection

Digital sketch maps and mental mapping as a scientific tool for detecting the perception of citizens about their environment have a long tradition [15,30–32]. There are several areas from urban planning, anti-segregation studies up to behavioural geography which apply this technique [33–35]. From a methodological perspective based on Lynch's fundamental work [30], a determinative study on mental maps was carried out by Stanley Milgram [36], who applied the free recall technique, in which respondents had to draw mental maps on a blank paper. The only problem with this method was that people perceived the same places differently, so it was hard to compare result maps directly and it was difficult to extract information out of them. Recently, various and new data collection techniques were developed in mental mapping, such as purely quantitative survey methods, qualitative and non drawing-based interviewing techniques, free recall data collection methods based on freely drawn maps, oriented recall-map drawing techniques with supplemented interviews, and data collection methods based on existing maps and images [24,25,37]. It is important to emphasize, though, that individual views of an area may rely on a large number of variables, namely other variables like the mode of travelling, age, education and so forth also may influence the individuals, so mental maps can have and can reflect a great variety of results [3].

In order to qualitatively evaluate the environment, the combination of mental mapping and GIS also proved to be a useful tool [38–40]. It has been applied widely in qualitative geographic information analyses to depict spatial narratives of groups or individuals [24]. Contemporary researchers frequently apply this tool in emotional mapping [41], or as complementary means with spatial video geonarratives [42], or human sensory information [43].

To collect comparable mental map data on people's opinion, a web application was designed in the way that it would serve as a tool for creating digital sketch maps. The application was built on Google's native web API (application programming interface) with an increased drawing capacity made available by the Drawing Manager (the sketch mapping website is accessible here: bunmegelozes.amk.uni-obuda.hu/). The application was designed both as a website and as a mobile application, whereas voluntary respondents could use the platform without registration. To reach respondents, this survey application was distributed primarily through social media channels resulting a kind of sample bias in the sense that respondents naturally had to have online and map reading competencies. Although such motives does not necessarily affect research outcomes, we consider our survey, therefore, as a model experiment. Initially the respondents were requested to indicate their gender as—according to Doran and Burgess [3]—this fact may influence the perception of fear of crime significantly. After that, by following the instructions, the users could indicate places where they feel safe (the users could draw a simple, green-coloured polygon on the map around safe areas), and also they could indicate places where they feel fear of crime (by drawing simple, red-coloured polygons on the map). In some studies, scientists asked the respondents to mark unsafe locations as points on the map [21,27]. Others reasoned that hot spots are emerging regardless of data representation, and they also proposed that sketch maps can be aggregated to a grid of cells across the study area [40]. Numerous authors, on the other hand, suggested the use of polygons instead of point representations, as in reality fear of crime appears rather in connection with smaller or larger areas and not with discrete point locations [24,38,44–46]. We followed this latter approach, assuming that the aggregated view of sketch map polygons could provide a spatially more representative picture of the geography of fear of crime.

After collecting digital sketch map data, altogether sixteen cities were possible to be investigated, from which those nine were chosen, where the number of respondents were at least 50 (reaching at least one thousandth of the local population). The original idea was to conduct this research in cities, which represent different urban size categories in Hungary, meanwhile keeping the possibility to compare them. Consequently, we selected a couple of cities both from large categories with population numbers between 100–160 thousand (Szeged, Miskolc, Nyíregyháza, Székesfehérvár), from medium categories with 40–50 thousand people (Nagykanizsa, Dunaújváros), and from small ones with 10–20 thousand residents (Keszthely, Balmazújváros, Heves). Large, medium and small-sized categories have been determined in the Hungarian context [47], from which the extreme large and unique category of Budapest was excluded, while also cities and villages with less than 10 thousand people were not represented.

The second pillar of our dataset was constructed of crime data, which have been categorized into 110 crime types according to Hungarian regulations [48]. In further data analysis, though, we applied only the categories of property crimes and crimes against people, and did not take into consideration those, which cause no direct fear among the citizens (e.g., "white collar crimes" such as banknote counterfeiting, offence against the order of the election, stamp forgery etc.). The involved crime types were, e.g., murder, physical assault, rape, theft, car burglary, pickpocketing, hooliganism, drug related crimes or public order offenses, etc., which all could have been associated with a particular location. No distinction was made between crime types, just the aggregated numbers were used, though we are aware of the fact that different crime types may have different spatial patterns or impacts on fear in a location [49,50]. The knowledge of the respondents' reason of marking a place unsafe would possibly ease this limitation of the study. Beside the type of crime, the geolocation of data was also provided by the Hungarian police on the level of addresses and geocoordinates. The final database for our selected cities contained 101,206 crime incidents.

2.2. Data Preparation

Digital sketch maps drawn by the participants formulated several overlapping polygons (Figure 1). Although also raw data can be at least visually analysed, for further and deeper investigations additional transformations were needed.

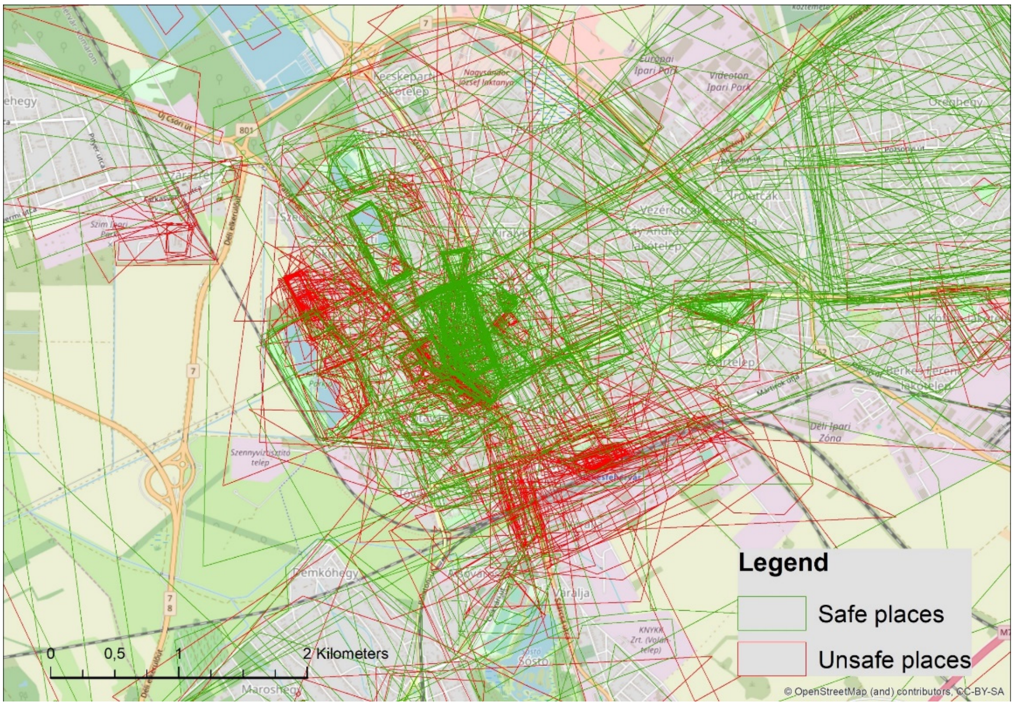

Figure 1. Polygons drawn by participants indicating safe and unsafe places in the survey in Székesfehérvár.

First, a 100 × 100 m grid was created over the whole polygon set in order to calculate the count of overlapping polygons in an area in each polygon groups. This was done by spatial joining the polygons to grid cells. Since original polygons had attributes of the city they belong to, as well as the safe or unsafe markings and the respondent's gender, the grid values represented the local count of men, women, safe and unsafe cases. By combination of field characteristics, the polygon-count of further subgroups could have been determined (e.g., count of safe polygons marked by women, etc.) for each city in the study.

Secondly, as we were aiming at analysing urban distribution characteristics of grid values, grid cells were needed to be dropped, which referred to uninhabited outskirts, like water bodies or agricultural lands. To do that, the CORINE Land Cover 2018 database was used for clipping out artificial surfaces, hence further investigations focused only on built-up areas. Although residents could have marked some outer locations as safe or unsafe intentionally, such examples were quite rare, otherwise would have resulted large distortion in urban value distribution.

In the next step, grid data have been normalized in order to make city results comparable. In each city, therefore, the local maximum value of grid cells was assigned by 100 and all other values were calculated as relative to the maximum value on the 0–100 scale. This was done both for safe and unsafe grid categories.

In parallel with the above-mentioned, the point-based crime data were processed with kernel density estimation (KDE) methodology by using search radius of 300 metres respectively. We followed examples of previous studies [40,51], since we agree that fear of crime appears not specifically at exact locations of former crime events, but rather in their not too distant surroundings.

After that, the previously created grid was overlaid on the kernel density map of crime events, and then each grid cell received the value from the KDE map, which was measured in the position of the cell's centroid. Grid values were also normalized to a 0–100 scale, in order to be appropriate for comparing results of different cities.

Finally, by having the grid based fear of crime and crime incident data, the possibility was given to compare the grid-level numbers. As outcomes, calculations were made both between the absolute number of safe or unsafe markings and crime events, and the relative (normalized) number of markings and crime events.

3. Results

3.1. Spatial Pattern Analysis of the Opinions of People

As mentioned above, digital sketch map polygons drawn by the users were overlapped and aggregated in each city to a 100 × 100 m grid. The value of the grid cells, consequently, represented the total number of the counted polygons normalized in reference to the maximum observed value in each city. It was expected that the normalized values of the grids vary significantly in different areas of the observed cities, in line with that, result maps reflected certainly not random but structured spatial pattern of values. Distribution maps of places marked as safe or unsafe have been created for each of the nine cities, and the results of three of them (a small, a medium and a large city) are presented on map series of Figure 2.

Although both the size and the shape of the cities are varied, the most significant places of fear of crime and safety are still easily determinable. Spatial concentration of high values, as well as geographically dispersed distribution of low values appear on city maps. The concentration of grids with high values may reflect that many of the users evaluated the covered locations similarly (the same dangerous or same safe), while the dispersion of low values may indicate different but not robust opinions of respondents. We applied these results as key starting points for our further analysis.

Additionally, since attributes of the respondents' sex was also given in our dataset, an obvious possibility was to test, whether any differences exist between male or female drawn maps, namely between the two group's local perception of fear or safety. Figure 3 was created by comparing the number of male or female respondents, who marked a territory safe or unsafe in one of our analyzed cities. This representative result shows pale differences between male and female respondents' judgment of places, suggesting that fear of crime is better explained by space rather than gender.

On the other hand, notable differences are appearing in further dimensions. We found a common feature for all the cities that places of fear of crime or places of safety are typically differently located, which was an expected outcome. In order to have a comprehensive overview, we compiled sketch maps containing safe places with those marking unsafe locations. As a result, a grid map was created, where grid values were showing the difference between the number of sketch maps mentioning a certain location as safe and the number of cases mentioning it as unsafe. Therefore, where the map returned positive values it meant that more safe polygons were overlapping than unsafe ones (see red pixels on Figure 4.), while negative values represented larger number of unsafe overlapping polygons than safe ones (see blue pixels).

Both the calculations about differences of the absolute number of mentions (local counts) and the calculations about differences of the normalized (or relative) number of mentions (local relative counts) reflected significant spatial patterns with clearly identifiable hotspots of unsafe and safe areas. As a conclusion, we may interpret result maps as visual interpretations of the overall judgment of places.

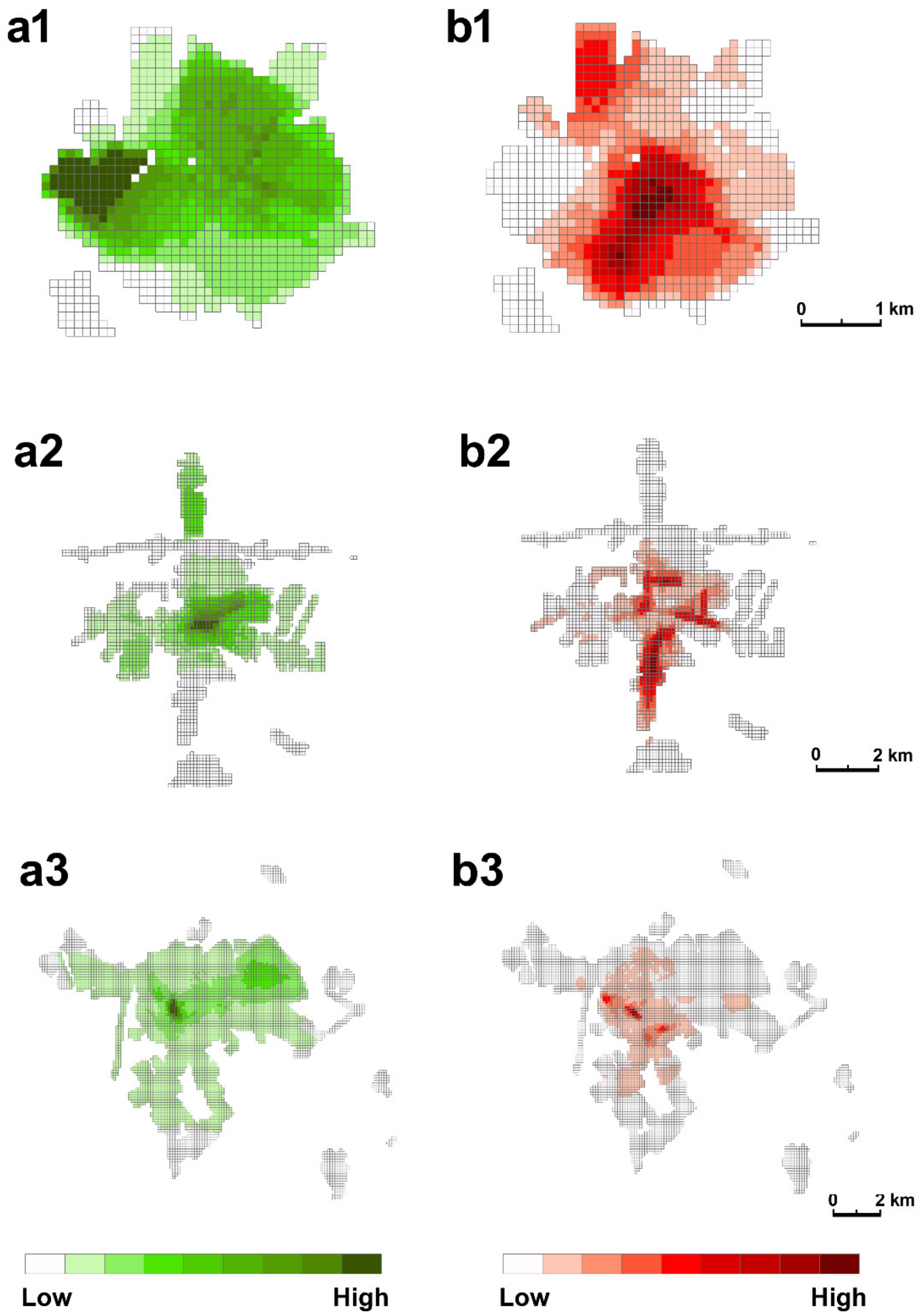

Figure 2. Local (normalized) number of times a place was marked as (**a**) safe or (**b**) unsafe (in some selected cities): (**1**) Balmazújváros; (**2**) Nagykanizsa; (**3**) Székesfehérvár.

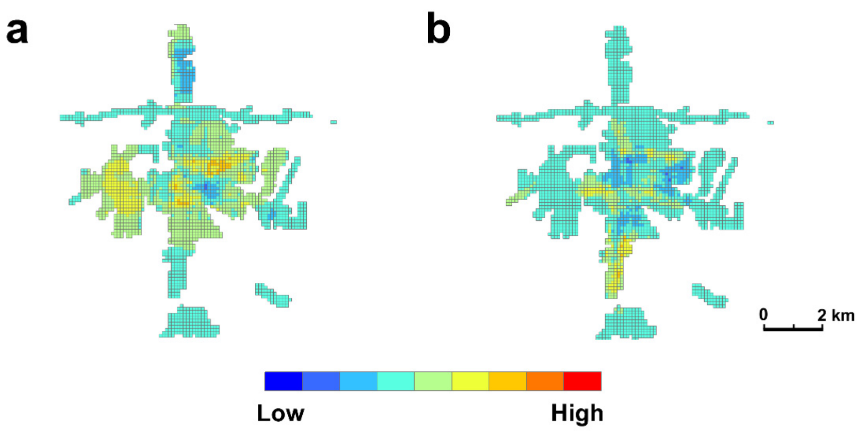

Figure 3. Differences between male and female respondents' judgment of (**a**) safe and (**b**) unsafe places. Higher values indicate more male, lower values indicate more female markings. Example city: Nagykanizsa.

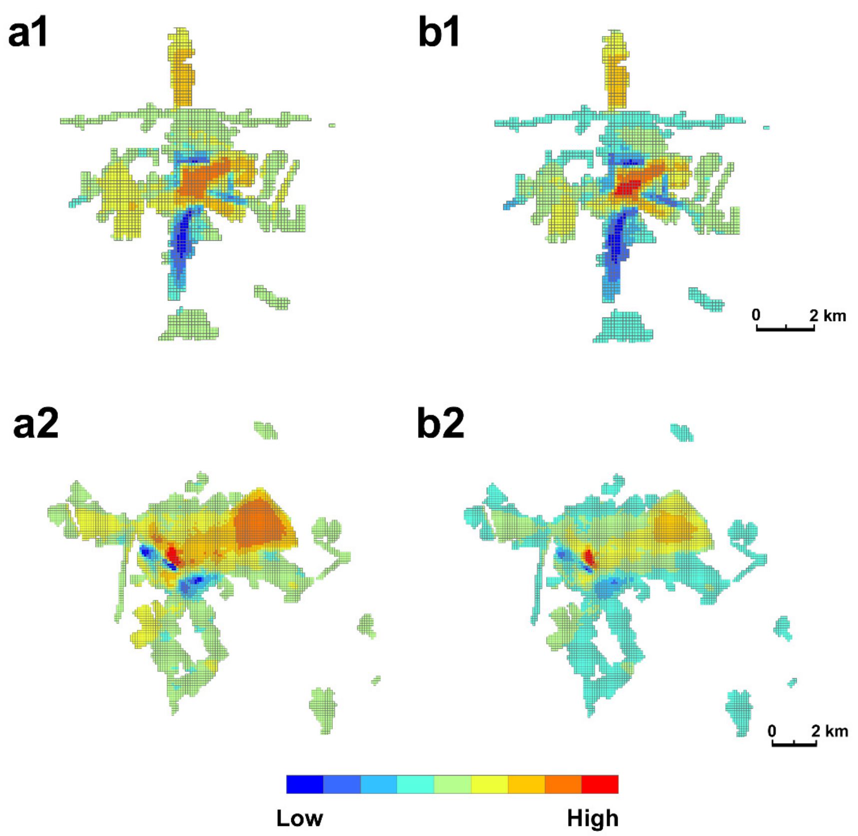

Figure 4. Local differences of place judgment: (**a**) local counts of marking a place safe minus local counts of marking it unsafe; (**b**) normalized number of marking a place safe minus normalized number of marking it unsafe. Higher values indicate safer, lower values indicate more unsafe perception. Example city: (**1**) Nagykanizsa, (**2**) Székesfehérvár.

3.2. Comparing Unsafety Patterns with Official Crime Statistics

Another possibility was to compare place judgment results with geographical patterns derived from police statistics. By comparing unsafe places marked by the citizens and locations of officially registered crime events one could discover some coincident places, suggesting that local people feel fear at locations, where—according to statistics—crime incidents happen. This is not a surprising result, however, one could also identify places, which were marked as unsafe by the respondents, but did not appear in the official police statistics. This, on the other hand, is rather an unexpected result, meaning that in certain areas people still feel fear, despite the fact that not many incidents are registered there. This suggests that the local environment has some kind of a negative effect on feeling safety, although it is also possible (but with lower probabilities) that not all the local crime incidents are reported and registered at those places referring to latent criminality [52,53]. A third type of result was, when the spatial pattern of fear of crime and the number of crime incidents had no significant covariance with each other neither in opposite nor in same direction. Figure 5 depicts examples representing the covariated, the oppositely moved and the independent relations between fear of crime and registered crime incidents.

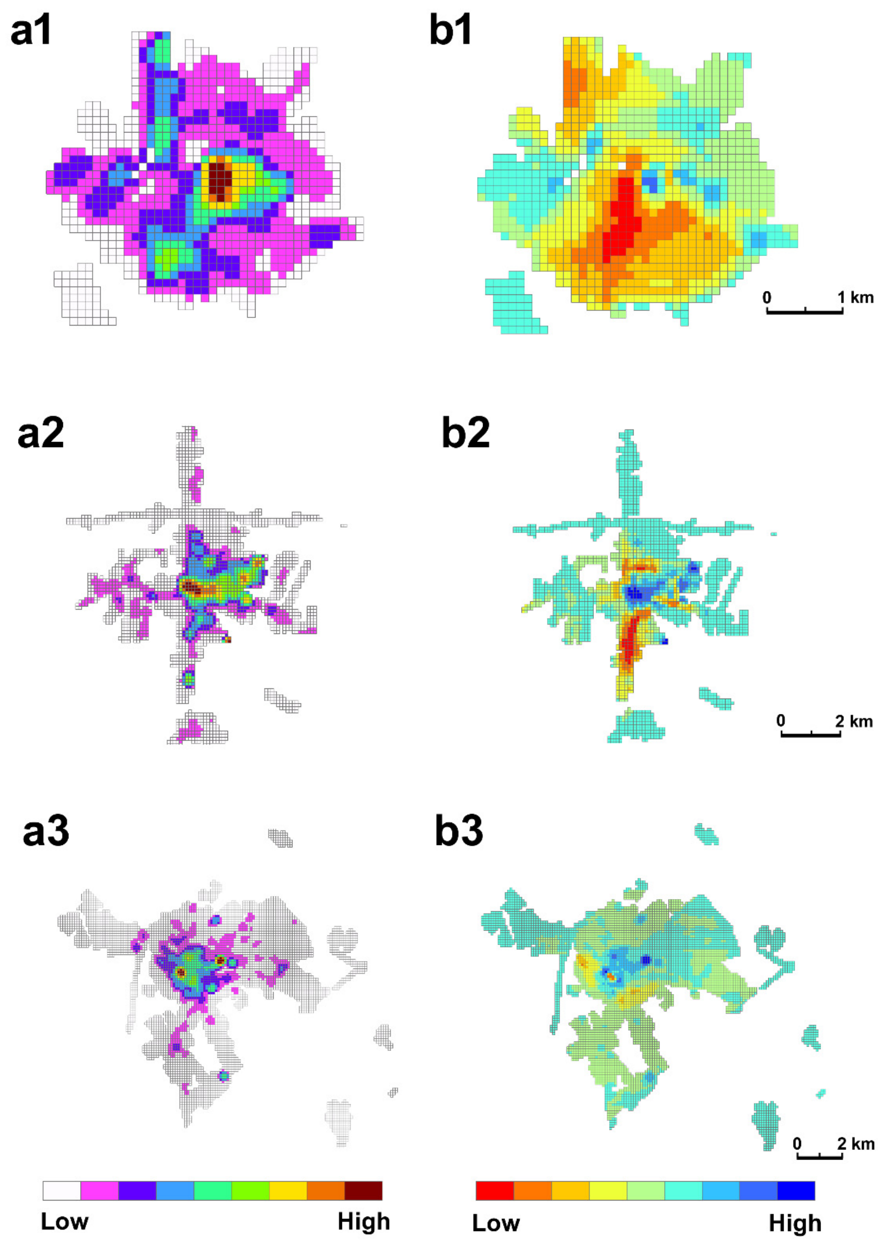

Figure 5. Crime density versus unsafety patterns: (**a**) spatial distribution of kernel density estimation (KDE) crime events (**b**); local number of KDE crime events minus local markings of unsafety, where low values indicate more unsafety markings than KDE crime events and high values indicate more KDE crime events than unsafety markings (in some selected cities): (**1**) Balmazújváros; (**2**) Nagykanizsa; (**3**) Székesfehérvár.

4. Discussion

The spatial pattern analysis applied visual means to show the territorial distribution of the examined phenomena. Although many conjectures were already verifiable (or possible to be proven), more accurate and objective conclusions could be drawn by examining rasterized data using statistical methodology. This approach is though rather different from previous crime GIS-related studies. In the following, we statistically examine the covariance and relationships of local indicator results on the level of grid units (or rasters) to strengthen and supplement conjectures about the geography of fear of crime.

As suggested by previous outcomes, the connection between the aggregated and normalized number of marking a location unsafe, and the number of registered crime events at a certain location can either be progressing in parallel or in an opposite way, or can be independent of each other. To confirm this mixed statement, pairwise Pearson correlation coefficients have been determined between the normalized number of registered crime events and the normalized number of marking a location unsafe, as well as the normalized number of marking it safe.

The table of results (Table 1) confirms the coexistence of the three types as depicted on Figure 5. The city of Balmazújváros is a good example on relatively strong connection between local unsafe markings and crime incident numbers, while having weak connection between crime events and local safe markings. It is, therefore, an example of feeling local fear, where crime events in fact happen, and perceiving safety, where crime incidents are rare, which is similar to some literature findings [46,54].

Table 1. Grid level correlation between the number of registered crime events and the normalized number of marking a location unsafe or safe in the observed cities.

City	N	Unsafe		Safe	
		Pearson Corr.	Sig. (2-tailed)	Pearson Corr.	Sig. (2-tailed)
Balmazújváros	972	,615 **	,000	,170 **	,000
Dunaújváros	2407	,311 **	,000	,493 **	,000
Heves	735	,517 **	,000	,128 **	,001
Keszthely	1211	,349 **	,000	,510 **	,000
Miskolc	4997	,076 **	,000	,281 **	,000
Nagykanizsa	2637	,396 **	,000	,690 **	,000
Nyíregyháza	6093	,428 **	,000	,341 **	,000
Szeged	6798	,353 **	,000	,631 **	,000
Székesfehérvár	4851	,560 **	,000	,462 **	,000
Total	30701	,372 **	,000	,381 **	,000

**. Correlation is significant at the 0.01 level (2-tailed). "N" denotes the number of grid cells in the observed area

Contrary to this expected result, an opposite situation is observable for example in Nagykanizsa, where the correlation coefficient between the number of crime incidents and the normalized number of marking a location safe is relatively high, compared to that the correlation coefficient with local unsafe markings is quite moderate. Such results reflect that in cities like this, local fear of crime should be in connection with other motives than typical crime frequency. In Nagykanizsa the city center had the highest number of crime incidents, whereas it was marked often as safe, of which a possible explanation could be the relatively high awareness of the area and the relatively high density of (day- or night-time) population. It assumes that crime frequency (at least certain forms of it) is in connection with population density [55], however, positive perception of places, as a result of nice, ordered and tidy neighborhood, may overwrite the feelings of safety. This assumption, though, should be tested by involving new datasets.

Finally, the city of Székesfehérvár can be chosen as an example of balanced connection between crime frequency and unsafe or safe markings. Both correlation coefficients mirror notable relationships between crime and safety feelings, which might be explained by mixed motives of marking a location safe or unsafe (see also [21]).

In general terms, correlation results reflect that safe and unsafe areas do not necessarily separate as "black and white" territories. This is because the opinion of many individual respondents become blurred and overlapped when drawing the map of fear of crime, however, in some cities clearer common mental representation of hotspots are identifiable.

By seeing the mixed character of local correlations with crime incidents the question rises, whether what counts in geographical differences of fear of crime. Sex could possibly be a more decisive factor, although Figure 3 already depicted insignificant spatial pattern differences between male and female respondents. By statistically evaluating the data, we strengthened this inference. Table 2 shows Pearson correlation coefficients between the normalized numbers of marking a location unsafe or safe by men and by women, which gives another aspect to the findings of Gilchrist et al. 1998 [7]. The correlation seems to be strong between male and female respondents' opinion when talking about their perception of unsafe places and this was the situation also when their marking of safe places have been examined. At the same time, we observed fairly low correlations if the number of unsafe markings had been compared with safe markings by all gender combinations.

Table 2. Grid level correlation between male and female respondents' markings of safety and unsafety.

Normalized Indicator	N	Pearson Correlation Coefficients			
		Unsafe (Male)	Unsafe (Female)	Safe (Male)	Safe (Female)
Unsafe (Male)	30701	1			
Unsafe (Female)	30701	,838 **	1		
Safe (Male)	30701	,098 **	,099 **	1	
Safe (Female)	30701	,093 **	,079 **	,839 **	1

**. Correlation is significant at the 0.01 level (2-tailed).

To get a more complex view, the overall picture of the rasterized fear of crime in cities should have been explained by multiple factors. Therefore, ordinary least squares (OLS) regression models were built across the 30,701 grid cells of the observed area in order to test the combined impact of the number of crime events, city size, gender-based opinion difference, and the overall normalized number of marking a place unsafe or safe. The models aimed to determine the explanatory role of the independent variables on the overall judgment of places, which was defined as the difference between the normalized number of mentioning a location safe and the normalized number of mentioning it as unsafe (that is the difference of the relative number of safe and unsafe mentions).

Altogether, nine model experiments were carried out, so that our general grid-based approach tested the explanatory role of several variable combinations (Table 3). Initial calculations (Models 1 and 2) applied the number of crime incidents and city size (measured as the population of the city the grid belongs to) as individual independent variables, however, with very low standardized beta coefficients and explanatory powers. In addition, the combined effect of crime events and city size returned relatively low values (Model 3). It seems, neither the number of registered crime incidents [26] nor the size of the city influenced too much the overall judgment of a location, when no other variables have been involved in explanatory regression models. Next, the effects of gender-based opinion differences on place judgment were tested (Model 4). The difference between the normalized number of marking a location unsafe by men and by women, as well as the same difference values for safety returned again low beta coefficients as independent variables. Additionally, when taking the number of registered crime incidents, city size and gender differences simultaneously into account, the explanatory power of the model still remains low (Model 5).

In the next step, we aimed to examine to what extent the number of considering a place safe (or unsafe) can influence the overall judgment of a location. We are aware of the fact that place judgment value is one sided dependent on the number of considering a place safe (or unsafe), however, this time we concentrated on the mass concentration of safe (or unsafe) mentions at the observed location, assuming that the volume of safety (or unsafety) mentions has a determining role itself in the overall evaluation of a place. For example, the overall judgment of a place can be high, when a medium large number of safety stands against a low number of unsafety, however, the same judgment result appears, if a very large number of safety coincides locally with a medium large number of unsafety. The balances of the two cases are equal, but the scales of positive and negative mentions are different.

Table 3. Ordinary least squares (OLS) regression results in determining the overall perception of locations.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
CRIMEEVENT	,092		,112		,098			−,236	,338
	(,000) **		(,000) **		(,000) **			(,000) **	(,000) **
CITYSIZE		,106	,124		,135			,061	,068
		(,000) **	(,000) **		(,000) **			(,000) **	(,000) **
UM_UF				−,008	−,001			−,042	,042
				(,177)	(,796)			(,000) **	(,000) **
SM_SF				,115	,118			,005	,109
				(,000) **	(,000) **			(,113)	(,000) **
SAFE						,787		,875	
						(,000) **		(,000) **	
UNSAFE							−,537		−,658
							(,000) **		(,000) **
N	30701	30701	30701	30701	30701	30701	30701	30701	30701
ADJ R2	,008	,011	,023	,013	,037	,619	,288	,674	,403
SEE	21,814	21,783	21,649	21,759	21,498	13,527	18,480	12,498	16,924
VIF (max)	1,000	1,000	1,027	1,002	1,049	1,000	1,000	1,225	1,205

Dependent variable is the difference between normalized numbers of marking a location safe and unsafe (overall judgement of location). Independent variables: normalized number of registered crime events (CRIMEEVENT); city size (CITYSIZE); difference between normalized numbers of marking a location unsafe by male and by female (UM_UF); difference between normalized numbers of marking a location safe by male and by female (SM_SF); normalized number of marking a location safe (SAFE); normalized number of marking a location unsafe (UNSAFE); p-values are reported in parentheses beneath coefficients; ** denote statistical significance at the $p < 0.01$ level; only the highest variance inflation factor (VIF) results are provided.

Initially, we tested the sole effect of the normalized number of considering a place safe (Model 6). The calculations returned very high and positive beta coefficients along with high adjusted R-square values, meaning that the volume of mentioning a place safe—already when taking solely into account—has a decisive influence on final place judgment. The situation was not that groundbreaking in the case of the normalized number of considering a place unsafe (Model 7), however, its influencing role still can be considered as important.

Our final models then examined the combined effect of the number of crime events, city size, gender-based opinion difference, and the overall normalized number of marking a place safe or not safe. The mixed variable set resulted an improvement in the explanatory power of the models, with a slight increase in the effect of the number of registered crime events, while the normalized number of considering a place safe (or unsafe) stayed as the most important independent variable (Models 8 and 9). For OLS regression diagnostics (beside adjusted R-square and standard error values of the estimation) also VIF statistics were tested, according to which no problematic multicollinearity was observed among the applied variables in any of the models (see bottom lines of Table 3). To sum up, we found that the overall balance of the perception of local fear of crime is largely depending on how strongly they were positively judged, and in some cases the local number of registered crime events also counts, however, this factor is much less decisive. City size, as well as gender differences of the opinions did not appeared as influential motives.

5. Conclusions

By the assistance of digital sketch maps, we investigated the perception of fear of crime and safety in a couple of large, medium and small sized Hungarian cities. Our grid-based normalised model made different city results comparable, and came up with some similarities and differences between the observed cities.

In the nine selected cities for observation, we found significant coincidences of crime statistics and perception of unsafe places, while in some other cases even the opposite correlation was evincible or the relationship between safe or unsafe places and crime frequency was mixed. These results highlighted the importance of locality in fear of crime research.

In searching for explanatory motives of fear of crime, we found that gender differences did not significantly influence the spatial pattern of unsafe or safe marking of places [3], rather geography matters, namely fear of crime is better explained by local environmental factors. By statistically evaluating the possible variables of explaining the overall judgment of places, we found that city size is less decisive in fear of crime differences, rather the absolute weight of safe markings and the local number of registered crime events could have some influence on local results.

Results of fear of crime analysis could have been improved definitely by involving larger number of cities (and respondents) in the analysis, hence the outcomes of the study is partly limited. Additionally, the applied digital sketch map tool collected information only about the location of safe and unsafe places, and provided no direct explanations why a place was marked safe or unsafe. The conclusions could have been improved if users have commented their markings. Limitations of the study comes also from the fact that fear could appear also in relation with dangerous crossroads or other traffic situations, which are sometimes difficult to be separated from crime related feelings.

Although many different viewpoints have been taken into account in our analysis, we believe, a possible improvement of the model could be achieved by implementing also points of interest (POI), traffic or high-density population data that would further refine the results. Additionally, information about the socio-cultural background of districts (such as ethnicities) would provide more in-depth explanation of the findings. An additional possible recommendation for future researches is to test spatial effects more deeply for example with spatial lag models.

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