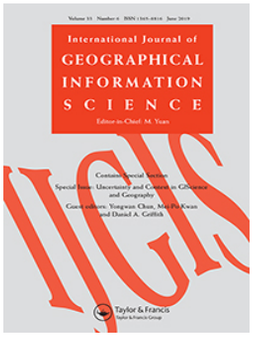

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RESEARCH ARTICLE



# Same space – different perspectives: comparative analysis of geographic context through sketch maps and spatial video geonarratives

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**ABSTRACT**

The importance of including a contextual underpinning to the spatial analysis of social data is gaining traction in the spatial science community. The challenge, though, is how to capture these data in a rigorous manner that is translational. One method that has shown promise in achieving this aim is the spatial video geonarrative (SVG), and in this paper we pose questions that advance the science of geonarratives through a case study of criminal ex-offenders. Eleven ex-offenders provided sketch maps and SVGs identifying high-crime areas of their community. Wordmapper software was used to map and classify the SVG content; its spatial filter extension was used for hot spot mapping with statistical significance tested using Monte Carlo simulations. Then, each subject's sketch map and SVG were compared. Results reveal that SVGs consistently produce finer spatial-scale data and more locations of relevance than the sketch maps. SVGs also provide explanation of spatial-temporal processes and causal mechanisms linked to specific places, which are not evident in the sketch maps. SVG can be a rigorous translational method for collecting data on the geographic context of many phenomena. Therefore, this paper makes an important advance in understanding how environmentally immersive methods contribute to the understanding of geographic context.

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GIS; spatial video geonarrative (SVG); sketch maps; geographic context

## Introduction

It is now widely accepted that official quantitative spatial data, such as commonly used in crime or health analyses, has limitations for the identification of both problems and the causal mechanisms to inform solutions. These data lack context, the insights of those who can best explain where and why these data points occur, what the implications are and how various social systems weave together through these locations. A major challenge lies in how to capture the geography of these types of insights. Many methods have been employed in this endeavor, and it is now appropriate to begin the process of assessing them in comparison to one another with the aim of identifying

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Supplementary data for this article can be accessed here.

their contributions to understanding entrenched social problems. Therefore, the aim of this paper is to make progress in this area through comparison between a traditional and an emergent method in a case study with criminal ex-offenders.

A long-standing approach has been to use sketch maps to tap into people's knowledge, preference, perceptions and behaviors. More recently, different technologies have allowed for more sophisticated ways to capture even greater depth by having a participant interact with his/her environment and using its stimuli to trigger both spatial and social insights (eg Kwan and Ding 2008, Evans and Jones 2011, Mennis *et al*. 2013). While initial results have been exciting, there remains much to do in terms of evaluating how these stimuli, spatial recall, experiences and the methods themselves influence our understanding of geographic context. We also need to see how the more logistically challenging and expensive methods compare against those that are cheaper, quicker and more widely accessible. Therefore, in this study, we collect spatial video geonarratives (SVGs) from 11 ex-offenders for one neighborhood and compare results with the sketch maps created by the same participants during the same time. These results are compared against police calls for service, which has previously been used to create hot spots through keyword selection. Then, in the discussion, we focus more on the content of the narratives in search for an explanation of where we find variations between these different data layers and to what degree is our search for more meaningful geographic context furthered using this method.

## *Geospatial methods for geographic context*

This study responds to the call for further research into methods for mitigating the uncertain geographic context problem (Kwan 2012a, 2012b). In particular, it builds on existing work on geonarratives (Kwan and Ding 2008) and their potential to address the recognition that data relevant to solving real-world problems must reflect the real-world spatial-temporal dynamism in people's daily lives (Kwan 2013). To achieve this aim, this study begins with a traditional approach, sketch mapping. This long-standing and widely accessible technique for accessing the geography of participants' knowledge, preferences, perceptions and behaviors can be implemented in a number of ways, though often by giving people a base map with some basic spatial reference information (eg roads) and then asking them to mark locations in response to specific questions (Curtis 2016). Although sketch mapping is grounded in work from the 1960s and the 1970s (Lynch 1960, Gould and White 1968, Gould and White 1974,Downs and Stea 1974), it is experiencing a resurgence, in part through integration with GIS. Recent examples include applications toward understanding environmental risks (O'Neill *et al*. 2015), public health (Beyer *et al*. 2010, Manton *et al*. 2016) and most prominently in crime/fear of crime (Doran and Lees 2005, Lopez and Lukinbeal 2010, Doran and Burgess 2011, Curtis *et al*. 2014). Although sketch maps make a number of contributions such as opening opportunities for countermapping perspectives, or the generation of detailed spatial information of individuals, and facilitation of data interpretation (Boschmann and Cubbon 2014, p. 236), little is known about how the results from this method compare to other approaches aimed at understanding geographic context.

Moving from more widely accessible methods, such as sketch mapping, to those that leverage emergent geospatial technology, an advance that is showing promise toward

understanding geographic context is the idea of geographically placed narratives (commonly, but not always, termed 'geonarrative' or 'geo-narrative').[1] This approach seeks to integrate narrative analysis with a geographic frame, specifically through modern geospatial technology, for the locations of features, events, behaviors, etc. (Kwan and Ding 2008). Foundational work in this area has taken different forms, such as combining participant sketch maps with travel diaries and audio-recorded narratives of Muslim women (Kwan and Ding 2008) to risk in activity spaces of youth identified through Ecological Interviews (Mennis *et al*. 2013). Building on the insight that these existing methods have contributed to spatial and even spatial-temporal processes, researchers are now moving to embrace the idea of geographic embeddedness or emplacement, collecting data with participants as they move or are moved (eg walking, driving) through a particular place or space (Elwood and Martin 2000, Anderson and Jones 2009). For example, Jones and colleagues (2008), Evans and Jones (2011) and Bergeron *et al*. (2014) have examined issues surrounding planning, redevelopment and place attachment. In addition, Bell and colleagues (2015, 2017) have utilized 'go-along' interviews to identify activity spaces and understand green space and blue space experiences. Others have utilized such methods to examine environmental activism (Anderson 2004), health–place relationships (Carpiano 2009), urban renewal and aging (Lager *et al*. 2013), and even walking itself, especially among those with disabilities (Butler and Derrett 2014). In particular, the work of Evans and Jones (2011) is germane to understanding the impact of geographic embeddedness on interview methods. They generated 'spatial transcripts' linking GPS to audio recording in walked interviews and compared the content to sedentary interviews and those who participated in both types of interviews. The spatial transcripts were overlaid in a GIS to visualize multiple participant input over places. Their results show that in comparison to sedentary interviews, interviews conducted while walking through the environment are quite different, with the embedded interviews yielding more geographically specific features as well as more explanation.

In response to the growth of this vein of methodological inquiry, it is important to be cognizant of the thoughtful critiques that are emerging. These include probing data accuracy (Merriman 2014), participant safety (Carpiano 2009) and participant exclusion. More recently, Warren (2017) provided evidence of the need to approach this method more critically as it relates to a range of vulnerable populations and the need to pluralize the walking interview using a case study of Muslim women. Her study points to the need for reflection on who is likely to participate in such an interview given domestic and other caregiving responsibilities of women; likewise, such reasons may also influence which researchers can use this approach. In sum, not everyone wants to be visible in her/his community for a variety of reasons, nor will all feel comfortable leading such an interview – determining the route and openly sharing thoughts inspired by the environment, which can be based on a range of social and cultural reasons.

While we recognize and appreciate the potential limitations of embedded interviews, for this study we believe our participants provide a suitable set of subjects to consider the complex interactions of crime in their home neighborhood of a medium-sized midwestern city through a further methodological advance on embedded techniques, the SVG.

SVG shares the intention of many extant sketch map applications, but is also closely aligned with the emergent work on geographically embedded mobility. Specifically, it is an outgrowth from the geonarrative/geo-narrative through the use of GPS-encoded audio and video data. SVG has been used by the authors in a variety of different environments to capture local context (Curtis *et al*. 2015, 2016, Krystosik *et al*. 2017, Schuch *et al*. 2017). Participants are professionals, residents or others with an intimate understanding of the environment being traversed. Typically, a car with between two and five spatially enabled cameras captures the passing environment while the participant narrates his/her comments responding to various stimulation of the senses. While visual cues are the most frequent conversation generator, sounds and smells and even 'feelings' have also led to a topic being discussed. The content of this narrative covers distant past, recent and current experiences, while in some cases the expertise of the individual is used to interpret what is witnessed. Following from protocols established in prior research, content from these narratives is assigned to one of three categories: spatially specific, where precise locations are pointed out and described; spatially fuzzy, meaning the comment is directed toward the general area; and spatially inspired, where the comment is not spatial (though it may mention other spatial locations) (Curtis *et al*. 2015, 2016).

With implementation of these methods and their variants toward the objective of improving understanding of geographic context, it is appropriate to begin the process of assessing them in comparison to one another with the intention of identifying their strengths and limitations. Therefore, the aim of this paper is to make progress in this area through comparison between the traditional sketch map and the emergent SVG in a case study with criminal ex-offenders. Specifically, we ask the following questions: 1) What is the geography of high-crime areas identified by the sketch maps in comparison to the SVGs? 2) How do the descriptive attributes of these places derived from sketch maps and SVGs compare? 3) What do each of these datasets contribute to understanding the geographic context of crime in this community? Answers to these questions are then more fully considered using the richness of the narratives to tease apart how sensory stimulus and personal experience result in a contextualized map.

## Materials & methods

This study reports on one aspect of a larger investigation on Offender Decision-Making using Geo-Narratives, which aims to create new understanding of the geographic context of crime covering many areas of the city. All participants were recruited in connection with a faith-based nonprofit organization in this community and were selected based on their local knowledge of crime in the area. The established relationship between researchers and this organization and the snowballing approach employed led to a relatively easy recruitment process. They were told the intention of the study was to assess how the neighborhood environment contributed to crime. They were compensated with twenty-dollar gift cards, and this compensatory payment was noted at the outset. Informed consent was obtained by all in accordance with Kent State University Institutional Review Board approval for this project (#13-522).[2]

## Participants

Sketch maps followed by an SVG were collected from 11 ex-offenders over a short period of time (July–September 2015) for the same neighborhood. Each of the participants had been charged for drug dealing, 10 out of the 11 had been involved in prostitution and nine out of the 11 had committed burglary. Other common activities in which they had personal experience include theft, robbery, shootings and gang involvement (Table 1). The SVGs would reveal that these crimes/activities could actually be considered symptoms of drug addiction as each was a recovering addict.

## Data collection

Data collection occurred in three stages: demographic survey, sketch map and SVG. The survey was composed of four pages (Supplementary Material – Appendix A). Participants were asked to fill out seven background questions that documented their age, sex, race, ethnicity, nativity, home ownership status in the community and educational attainment. Then they completed a sketch map. Each participant was given a legal sized map of the study area at a scale of 1:10,000 so that road names were clearly visible. Participants were instructed to use three colors for their markings: red for high-crime locations, green for crime-free areas and blue for locations where they were likely to spend time (this originally was a yellow marker, but blue was more visible, so this color was utilized instead). The participants were also asked to number each marked area and on the back of the map, write down the prevalent crimes for the labeled locations. A digital copy was made of each paper sketch map before being georegistered using TIGER Line road data for the study area in ArcGIS 10.4. The markings of each participant were digitized as polygons from the georegistered maps and characteristics written about each location added in the attribute table (Curtis *et al*. 2014).

**Table 1.** Participant demographics.

| ID | Connection | Years | Age | Gender | Race | Criminal offenses |
|---|---|---|---|---|---|---|
| B070315 | RESIDENT | <1 | 47 | F | WH | Drug dealing, Burglary, Gang Activity, Car Theft, Prostitution, Robbery, Drug use |
| B072115 | RESIDENT | <1 | 29 | F | PI | Drug dealing, Burglary, Gang Activity, Prostitution, Fighting, Robbery, Drug use |
| 072115 | RESIDENT | 10+ | 39 | F | WH | Drug dealing, Burglary, Gang Activity, Car Theft, Prostitution, Fighting, Robbery, Drug use, Shootings |
| B072315 | RESIDENT | 10+ | 55 | F | BL | Drug Dealing, Prostitution, Fighting, Robbery, Drug Use, Shootings |
| 073015 | VOLUNTEER | 10+ | 35 | F | WH | Drug Dealing, Burglary, Prostitution, Fighting, Drug Use, Shootings |
| B073015 | RESIDENT | <1 | 47 | F | WH | Drug Dealing, Burglary, Gang Activity, Car Theft, Prostitution, Robbery, Drug Use |
| 080715 | RESIDENT | 1–3 | 41 | F | WH | Drug Dealing, Burglary, Car Theft, Prostitution, Fighting, Drug Use |
| B090815 | RESIDENT | 10+ | 32 | F | WH | Drug Dealing, Gang Activity, Prostitution, Fighting, Robbery, Drug Use (former dealer, heroin addict) |
| 070915 | RESIDENT | 7–9 | 40 | M | WH | Drug Dealing, Burglary, Prostitution, Fighting, Robbery, Drug Use, Shootings, Rape, Gambling, Sex Trafficking |
| 072315 | RESIDENT | <1 | 29 | F | PI | Drug Dealing, Burglary, Gang Activity, Prostitution, Fighting, Robbery, Drug Use Shootings |
| 101615 | VOLUNTEER | 10+ | 45 | F | W | Drug Dealing, Burglary, Prostitution, Drug Use |

After completion of the survey and sketch map, the interviewer asked if the participant would feel comfortable taking them to the high-crime areas/places that s/he had identified on the map. At this point, the SVG ride began with one researcher driving while the participant sat in the front seat and at least one other researcher sat in the back seat overseeing equipment and helping with questions. At least one female researcher was always in the car. The interviewer would ask some general opening questions, such as, *we would like you to describe the areas identified on the maps, and whatever else you see or comes to mind during the drive*. The participant was then left to dictate the route. As much as possible, the interviewer restrained himself/herself to clarifying questions, prompting questions in moments of prolonged silence, directional clarification and a few standard questions such as *What do you think could be done to improve this neighborhood?* The car consisted of four spatial video cameras, two on either side, and at least two audio recorders. Once the ride was completed, all videos were downloaded and checked for image quality, audio clarity and GPS accuracy. These, in addition to the mapped route and overall camera performance, were turned into a standardized ride metadata sheet. The first audible word found on the audio and video media devices (which also had to have a valid GPS coordinate) was extracted to provide the linking needed for mapping.

## Analysis

Owing to the variety and nature of data collected and the objectives of this study, both quantitative and qualitative analyses were utilized. First, for the sketch maps, a grid was constructed for the study area (50 m x 50 m), and then a spatial join created a count of participant markings intersecting each grid cell. Heat maps were created based on these counts to aggregate individual participants' knowledge about areas of high crime into a collective picture of the study area (Curtis *et al*. 2014).

The SVG audio was transcribed with time stamps inserted before each comment, and this was merged with the GPS path using Wordmapper 2[3] software. Each narrative was read for themes, both topically (eg related to prostitution) and spatially. Wordmapper 2 was used to assign each comment as spatially specific (positive and negative), spatially fuzzy (positive and negative) and spatially inspired (positive and negative). For a comment to be spatially specific, the participant would have to identify or draw attention to a passing place, building or person. For spatially fuzzy, the comment would still be tied to the general proximity, for example a comment about the blight around these streets, with the remaining comments falling into the inspired category. The spatial output from Wordmapper 2 (Google Earth KML and comments shapefile) had this spatiality assignment identified as a colored pin (KML) or as a code in the attribute table (shapefile). For the purposes of this paper, all spatially specific comments about criminal activity were overlaid on the sketch map outputs.

Police calls for service had also been acquired as an alternative to more traditional crime-related data. A key word query for either 'drug related' or 'violence related' calls in effect generated a numerator file for a spatial filter analysis,[4] while the denominator was all calls. This analysis was for comparative purposes in terms of how *spatially* aligned were the ex-offender insights with official police data.

To answer the research questions, several additional manipulations occurred of the previously described data and analytical outputs. First, for each participant, high-crime areas identified through their sketch maps were overlaid with their SVG ride path (Supplementary Material – Appendix C), and the percentage of the route that intersected with the sketch map area was calculated (with the extent of the base map used in the sketch map digitized as a polygon). A spatial query then selected all SVG coordinates that intersected this base map polygon. This procedure was used to compare the geographic extent of high-crime areas as identified by the participants in the sketch map and the SVG. Then, in order to compare the spatial pattern of locations identified in the sketch maps and in the SVGs, all spatially specific crime locations were queried from the Wordmapper 2 shapefile output and buffered at 25 m, 50 m and 100 m. Three buffer sizes were used to provide different geographic scales around each identified coordinate location as the path GPS did not always sit on top of, or immediately proximate to, the location being described. These buffers provide a counter for such artificial precision. Again, a spatial query was performed to identify sketch map polygons that intersected the buffers. As the SVG was driven and limited to roads, a second spatial query was performed to identify polygons that were within 50 m of a buffered area, specifically to capture places that are not immediately proximate to the road (eg parks, apartment complexes, etc.). Finally, comparing and contrasting the attributes assigned to these spaces were accomplished through a count of the number and documentation of type of characteristics for each identified location.

## Results

Based on their local knowledge, the 11 participants marked 139 high-crime locations on sketch maps. To visualize these data, heat maps were constructed by overlaying the digitized sketch map markings (Curtis *et al*. 2014). A 50 m × 50 m grid was applied to enable aggregation of individual markings and create maps showing the continuum of spaces of concern, from where few participants marked an area to where many identified the same place (Figure 1). Three areas of some level of consensus are identified as Hot Spots A, B and C.

Although this approach can identify some common areas of high crime, examination of the size and shape of the participants' markings indicates varying geographies from specific locations along a street segment or within a city block to larger areas comprising several blocks. The descriptions of crime identified by the participants also vary within each of the three identified hot spots (Supplementary Material – Appendix D).

Note that in Hot Spot A, one participant writes 'drugs', while for another it is 'drug houses, drug sales' and a third states 'drugs (meth labs, heroin, drug dealing)', so in addition to what attributes are assigned to any particular area, there is also variation in the descriptions provided even about the same activity.

In comparison, the SVGs generate far more detail about places, events and times. To provide a direct comparison with the sketch maps, only the spatially specific negative comments were used. The spatially specific locations for each participant were extracted as a separate shapefile and buffered to three distances: 25, 50 and 100 m. There is a range of between 3 and 16 spatially negative buffers at the smallest buffer size[5] (containing between 5 and 91 comments) across the participants. Subject 080715 had

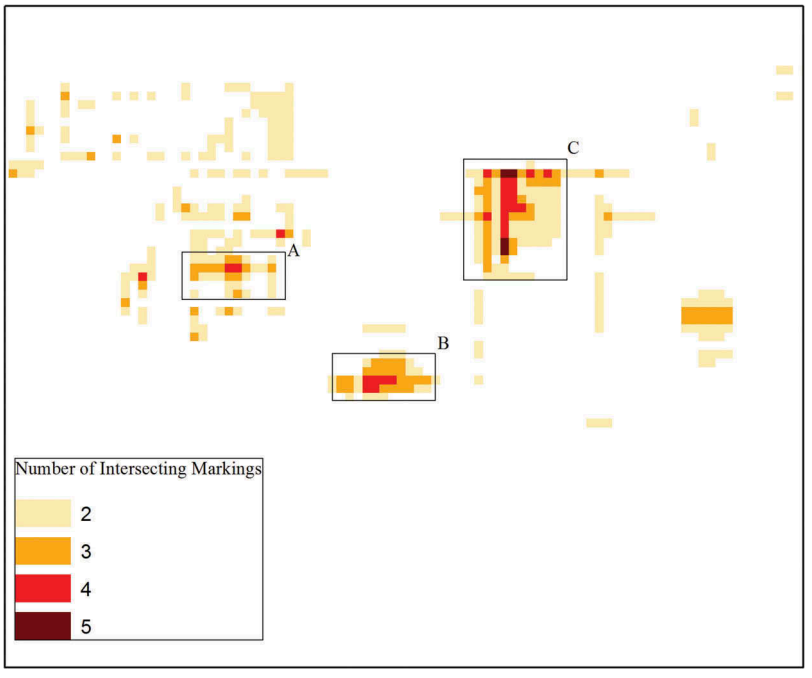


**Figure 1.** Hot spots of crime based on ex-offender sketch maps.

both the shortest ride and the fewest spatially precise mentions, with most comments being more general about the neighborhood. Interestingly, the number of buffers and the number of spatially specific mentions do not vary consistently. For example, there can be more detailed description of a smaller area or single descriptions of more scattered locations.

As a way to display the frequency of geographies occurring across all SVGs, a grid was overlaid on the map that would also be used for the spatial filter analysis. If a grid node fell inside a buffer, it received a count, the sum of which gave a distribution of how frequently that area was mentioned in the SVGs. These frequencies are displayed in Figure 2, with the highest number of overlays being 5, meaning five different test subjects mentioned at least one spatially significant negative location within 100 m of that grid point. This map is interesting in that it shows four locations (A, B, C and D) where there appears to be consensus among multiple participants as to clearly identifiable problem locations, with A revealing the highest concentration of consensus on problematic spaces and places.

To explore how these spatially specific SVGs compare with official data and a more aggregated way of working with SVG data, the spatially specific buffers were overlaid onto spatial filter output surface for calls for service. For the purposes of this paper, $p = 0.05$ for violence and drug calls for service spatial filter outputs are displayed. Figure 3 displays an area worthy of further discussion identified in Figure 2 as 'A'. Only the inner polygon of the buffer has been shaded so that multiple overlays can be seen together. These maps also show the results of the 2015 $p = 0.05$ spatial filter output. In Figure 3 (location A), the top left inverted 'L' displays three streets that

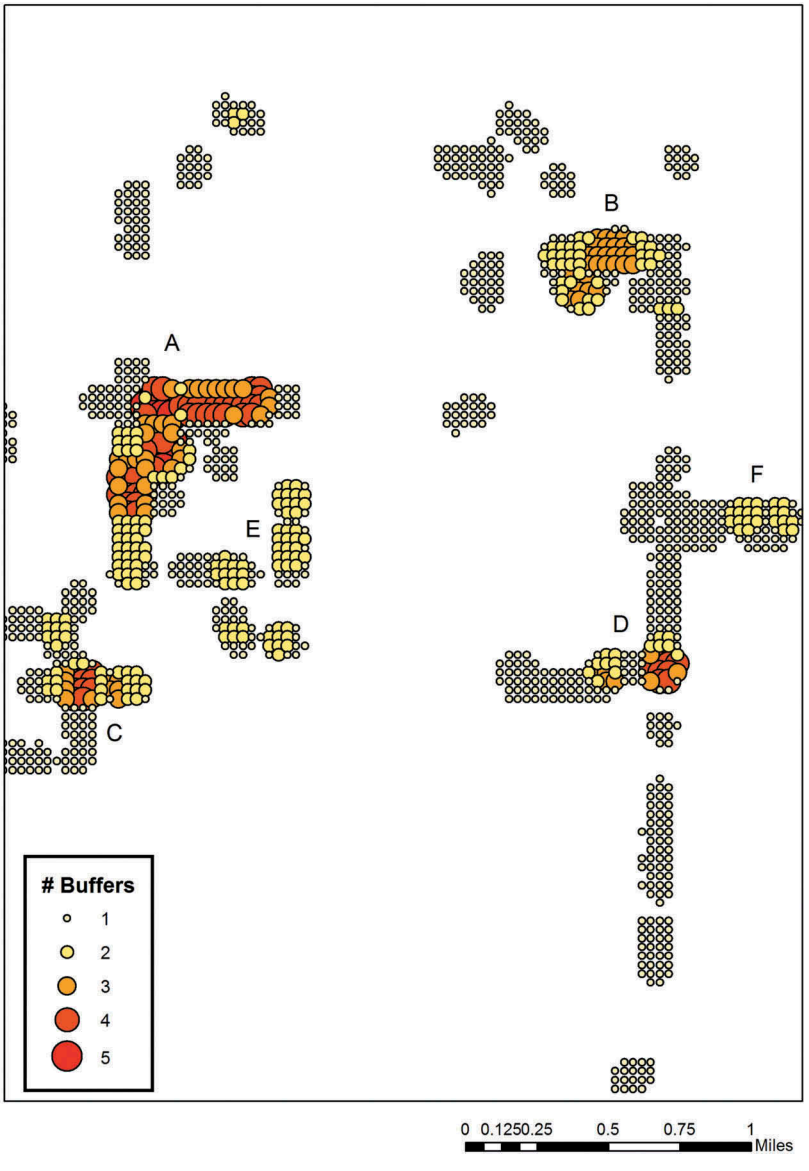


**Figure 2.** Frequency of spatially specific mentions.

received a high number of spatially precise negative mentions from six different SVGs, with three others being in close proximity. This same area also had statistically significant filter outputs for both drug and (especially) violence calls for service. This map also reveals other interesting patterns, for example the central area that has statistically significant filter output for violence-related calls for service, but no spatially specific mentions made in the vicinity by the ex-offenders. Location B in Figure 2 is also notable in that it has four participants' SVGs identifying spatially precise locations, and yet no statistically significant calls for service occur in this vicinity.

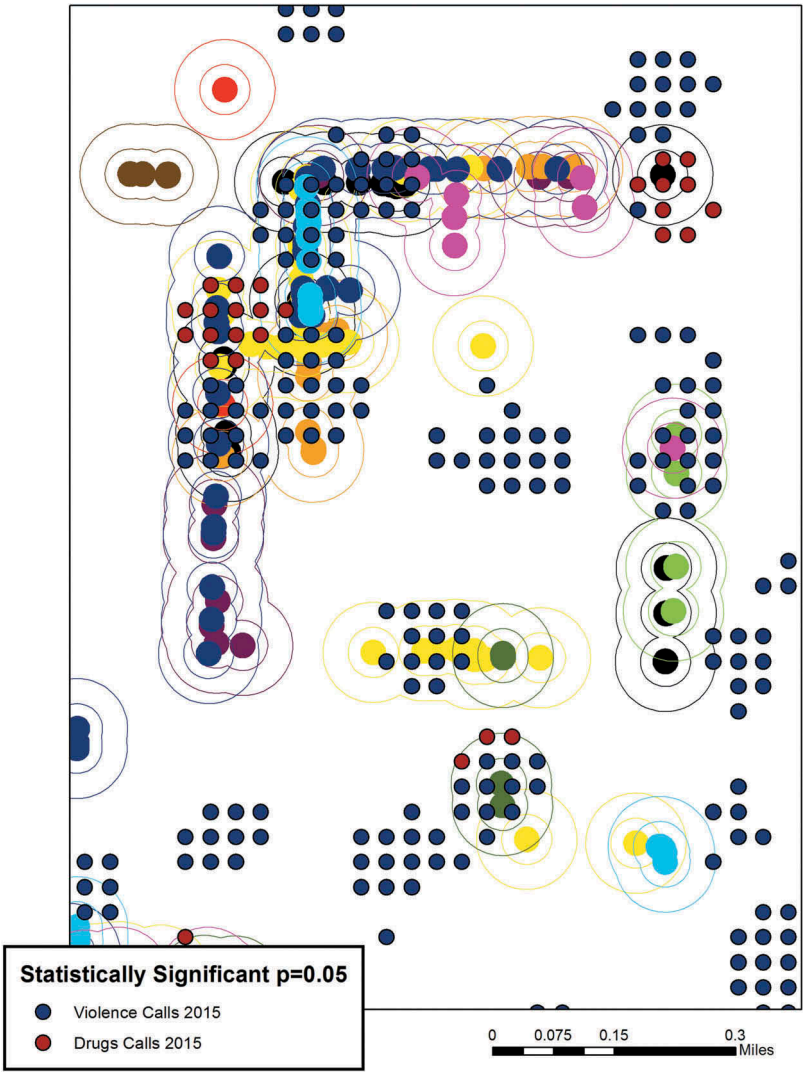


**Figure 3.** Comparison with 'Violence' and 'Drug' hot spots from calls for service. Dark blue points represent calls for service regarding violence, dark red points represent calls for service related to drugs, and all other points and buffers represent locations of SVG mentions.

Moving from separate to comparative investigation of sketch maps and SVGs, our first question is about the similarities and differences of their geography, both the geographic extent and then the places and patterns within these areas. Starting with the geographic extent, Table 2 provides a description of the continuity and discontinuity of space resulting from each method.[6]

The percentage of SVG routes directed by participants that are located off the researcher-defined sketch map area ranges from 0 to 59%, with a median of 32%. This means that there is a notable area of the neighborhood that is meaningful to the participants that was not even made available for them to include in the sketch map, despite researchers' due diligence to use an appropriate geographic extent in the base

**Table 2.** Comparison of sketch map to SVG data: continuity/discontinuity of geographic extent identified by participants.

| ID | SVG PATH (coordinate points) | OFF THE MAP | ON THE MAP |
|---|---|---|---|
| B070315 | 5756 | 1821 (31.64%) | 3935 (68.36%) |
| B072115 | 4484 | 1615 (36.02%) | 2869 (63.98%) |
| 072115 | 7733 | 4622 (59.77%) | 3111 (40.23%) |
| B072315 | 4415 | 1175 (26.61%) | 3240 (73.39%) |
| 073015 | 6961 | 2292 (32.93%) | 4669 (67.07%) |
| B073015 | 2860 | 0 (0.00%) | 2860 (100.00%) |
| 080715 | 4054 | 1308 (32.26%) | 2746 (67.74%) |
| B090815 | 3578 | 1730 (48.35%) | 1848 (51.65%) |
| 070915 | 7116 | 2232 (31.37%) | 4884 (68.63%) |
| 072315 | 6347 | 3603 (56.77%) | 2744 (43.23%) |
| 101615 | 5917 | 2534 (42.83%) | 3383 (57.17%) |

map. This result points to the limitation of using paper sketch maps as their extent is static, but it also raises the importance of testing more spatially dynamic data collection tools such as softGIS (eg Kyttä *et al*. 2013) and Maptionnaire (https://maptionnaire.com/) as well as other options that use digital base maps on tablet technology (eg Google Earth/Maps as a base map for sketch map data collection).

Moving from comparison of the overall geographic extent defined by the participants, the following section focuses on the geography of high-crime locations identified within the study area. All participant SVG paths intersected at least one of the high-crime locations each identified through their sketch map, though approximately half of the sketch map locations do not intersect or are not even proximate (within 50 m) to the spatially specific places identified in the SVG. This suggests that even when participants directed the SVG route through the same geographic areas identified on the sketch map, they were not consistent in identifying the same locations.

A further notable difference between results from the two methods is in what type of events was described and in what level of detail. The participants produced a more nuanced and deeper understanding of the neighborhood through the SVG. Comparison of the fourth and fifth columns in Table 3, which are the descriptions of high-crime locations in the sketch map and in the SVG, reveals stark differences.

First, the attributes assigned to places in the sketch map are often noted as general categories of criminal offenses, as opposed to descriptions provided in the SVGs that are more detailed. Then, the number of attributes identified in sketch maps and SVGs differs, with sketch maps producing from as little as three to a high of 14, while SVGs consistently generated more. Finally, the types of attributes assigned to places also differ. In the sketch map, the descriptions are primarily types of crimes, while in the SVG, they are about types of crimes, as well as specific people, places and spatial-temporal relationships related to the crimes. These observations are qualified by the fact that the sketch maps took no more than 10 min to complete and the SVGs often lasted up to 1 hour, so with more time, there is more opportunity for locating and describing places and processes. However, we suggest that even with equal amounts of time, SVGs would still lead to better data on geographic context. This is a question that should be investigated in future research.

**Table 3.** Comparison of sketch map to SVG data: number of places identified and excerpts of attributes for these locations. In SVG NUMBER, the first value is the number of buffered areas using the largest buffer and the value in parentheses is the number of buffered areas using the smallest buffer.

| ID | SKETCH NUMBER | SVG NUMBER | SKETCH DESCRIPTIONS | SVG DESCRIPTIONS |
|---|---|---|---|---|
| B070315 | 3 | 15 (30) | 1: DRUGS, GANGS<br>2: THEFT, LOITERING<br>3: DRUGS, VIOLENCE, BURGLARY-ROBBERY, AUTO THEFT | 1: DRUGS – CRACK<br>2: DRUGS – CRACK<br>2&3: DRUGS – CRACK<br>3: BUILDING ON THIS STREET SEGMENT WHERE DRUGS ARE SOLD<br>A: A STREET THAT HAD HIGH CRIME, BUT HAS IMPROVED<br>B: A LOCATION (NAME REMOVED) IN THE STREET SEGMENT THAT HAD HIGH CRIME, BUT HAS IMPROVED<br>C: STREET THAT WAS DANGEROUS AT NIGHT<br>D: BOUNDARY/TRANSITION ZONE BETWEEN LOW- AND HIGH-CRIME AREAS<br>E: ROUTE FROM HOME TO ACQUIRE DRUGS<br>F: STREET WITH PREVALENCE OF THEFT, AUTO THEFT, ROBBERY, ASSAULT<br>G: HOUSE WHERE DRUGS COULD BE PURCHASED<br>H: BOARDED HOUSE THAT IS A CRACK HOUSE<br>I: STORE WHERE DRUG DEALERS WERE PRESENT<br>J: APARTMENTS WHERE CRACK IS SOLD |
| B072115 | 6 | 8 (31) | PROSTITUTION<br>GANGS<br>SHOOTINGS<br>BURGLARY/ROBBERY | TALKING ABOUT SKETCH MAP: METH LABS, BURGLARY – A LOCATION IDENTIFIED ON THE MAP<br>A LOCATION ON THE MAP – PROSTITUTION<br>A: SHOOTINGS, CRACK AND DOPE USE<br>B: PROSTITUTION<br>C: BRIDGE – FOR DRUG USE BECAUSE THESE IS A 'HIDING SPOT IN THE BUSHES'<br>D: DRUG HOUSES<br>E: 'WHERE PEOPLE MEET TO GET DRUGS'<br>F: APARTMENTS WITH A METH LAB |

(*Continued*)

**Table 3.** (Continued).

| ID | SKETCH NUMBER | SVG NUMBER | SKETCH DESCRIPTIONS | SVG DESCRIPTIONS |
|---|---|---|---|---|
| 072115 | 6 | 8 (28) | 1: MURDER<br>2: THEFT<br>3: PROSTITUTION<br>4: GANGS<br>5: DRUGS<br>6: ROBBERY<br>7: ALL CRIME<br>(NUMBERS ARE NOT LABELED ON THE MAP) | A HOUSE WHERE DOPE WAS COOKED<br>BOARDED DOORS AS A SIGN THE METH IS COOKED THERE OR IT WAS A RAIDED CRACK HOUSE<br>BRIDGE FOR DRUG USE BECAUSE 'WE COULD JUST THROW OUR SHIT OVER THE SIDES OF THE HIGHWAY'<br>LOCATION OF SHOOTINGS<br>STREET WHERE IN THE PAST THE SMELL FROM DOPE COOKING WAS PREVALENT<br>HOUSE WHERE SPEED WAS BEING MADE – BASED ON SMELL<br>STREET WITH CRACK HOUSES AND PROSTITUTION DENS<br>STREET SEGMENT KNOWN AS 'THE HOE STROLL'<br>ANOTHER STREET KNOWN AS 'THE HOE STROLL'<br>LOCATION OF A DRUG SALE<br>HOUSE WHERE HEROIN IS SOLD<br>CORNER WHERE A CHILD WAS MURDERED<br>SCRAP YARD WHERE STOLEN METAL IS SOLD FOR MONEY TO BUY DRUGS<br>ADULT CINEMA WHERE THERE ARE PROSTITUTES<br>AREA WITH HOUSES THAT ARE BROTHELS<br>A BUILDING THAT IS 'ONE OF THE WORST PLACES FOR DRUGS'<br>AREA WITH PREVALENCE OF POT, ACID, COCAINE<br>STRIP CLUB WHERE MAJORITY OF DANCERS ARE ADDICTED TO DRUGS OR ALCOHOL<br>PLASMA – WHERE PEOPLE GIVE PLASMA FOR MONEY TO SPEND ON DRUGS |
| B072315 | 1 | 9 (60) | MURDER, GANGS, DRUGS, PROSTITUTION, HOMELESS, BURGLARY, FIGHTING, RAPE | APARTMENT THAT IS 'DOPE INFESTED'<br>GROUP OF BUILDINGS WHERE PEOPLE RENT ROOMS THAT ARE 'DOPE INFESTED'<br>STRIP CLUB AND SURROUNDING AREA THAT IS DANGEROUS<br>APARTMENT BUILDING WITH DRUGS<br>A DOPE HOUSE<br>STREET THAT IS A 'HOE STROLL' WITH DRUG SALES AND USE<br>GROUP OF APARTMENTS ON TOP OF BUSINESSES WHERE DRUGS ARE PRESENT<br>A DOPE HOUSE WHERE A MURDER OCCURRED<br>PARK WITH DRUG DEALERS<br>BUILDING THAT IS 'DOPE INFESTED'<br>AREA WITH METH HOUSES<br>APARTMENT WHERE DOPE IS SOLD<br>ABANDONED HOUSE BEING USED TO COOK METH<br>AREA OF DOPE HOUSES<br>A DOPE HOUSE |

(*Continued*)

**Table 3.** (Continued).

| ID | SKETCH NUMBER | SVG NUMBER | SKETCH DESCRIPTIONS | SVG DESCRIPTIONS |
|---|---|---|---|---|
| 073015 | 4 | 8 (56) | 1: DRUGS, PROSTITUTION, SHOOTINGS, ASSAULTS<br>2: DRUGS<br>3: DRUGS, PROSTITUTION, SHOOTINGS, ASSAULTS, BURGLARIES<br>4: DRUGS, SHOOTINGS, PROSTITUTION, ASSAULTS | LOCATION WHERE S/HE PARKED A CAMPER VAN TO COOK METH<br>ABANDONED HOUSE WHERE METH IS COOKED<br>HOTEL WHERE DRUGS ARE SOLD AND THERE IS A STRIP CLUB, DRUG USE, PROSTITUTION AND 'A LOT OF SEX OFFENDERS LIVE THERE'<br>STREET THAT IS NOT SAFE TO WALK IN DAY OR NIGHT DUE TO ROBBERY<br>VACANT HOUSE WHERE S/HE HAS SMELLED DRUGS COOKING AND THE GARAGE NEXT TO IT AND A NEARBY ALLEY<br>GROUP OF HOUSES WITH METH AND WHERE A SHOOTING OCCURRED<br>STREET WITH PROSTITUTION<br>STREET WITH DRUGS<br>GROUP OF STREET WHERE CRACK IS AVAILABLE<br>APARTMENT WITH PROSTITUTION<br>APARTMENT WITH DRUG DEALERS<br>A STREET THAT IS A 'HOE STROLL' |
| B073015 | 7 | 8 (36) | DRUG DEALING, SHOOTINGS, BEATING, STABBINGS, PROSTITUTION | HOUSES WHERE DRUG DEALERS LIVE<br>SHOOTING AROUND THE HOUSES WHERE DRUG DEALERS LIVE<br>A FIELD WHERE A GIRL WAS STABBED<br>A STREET WHERE PROSTITUTES WALK AND DRUGS ARE USED<br>BUILDING ON A CORNER WHERE HEROIN IS SOLD<br>HOUSE WITH BULLET HOLES<br>LOCATION WHERE ASSAULT WITH HAMMER OCCURRED AND IN THE SAME AREA A BLACK WOMAN MURDERED A WHITE MAN AND A SHOOTING. ALL DRUG-RELATED<br>PARK – SPECIFICALLY AT THE BASKETBALL HOOP DRUGS ARE SOLD<br>ALLEYS WHERE DRUG DEALS OCCUR<br>DRUG HOUSES<br>STREET WHERE DRUGS WERE BEING USED IN ABANDONED HOUSES, BUT HOUSES DEMOLISHED, SO THEY NOW USE A NEARBY FIELD AND GARAGES<br>BAR SHUT DOWN DUE TO SHOOTINGS<br>CORNER WHERE DRUGS ARE SOLD<br>AREA WHERE DRUGS ARE SOLD OPENLY |
| 080715 | 4 | 3 (5) | THEFT, DRUGS, FIGHTING, WEAPONS | STREET WITH PREVALENCE OF CRACK<br>AREA AROUND A BAR WHERE GUNSHOTS WERE OFTEN HEARD<br>STREET WITH DRUG DEALERS<br>RAILROAD TRACKS WHERE A WOMAN WAS BEATEN |

(*Continued*)

**Table 3.** (Continued).

| ID | SKETCH NUMBER | SVG NUMBER | SKETCH DESCRIPTIONS | SVG DESCRIPTIONS |
|---|---|---|---|---|
| B090815 | 6 | 5 (17) | 1: . . .ARE BAD DRUG AREAS<br>2: . . .BIKER CLUB AREAS<br>3: . . .PROSTITUTION AND DRUG AREAS | DRUG HOUSE WHERE HEROIN IS SOLD<br>HOUSE THAT LOOKS NICE, BUT 'LADY SELLS PILLS'<br>TWO HOUSES WITH DRUG ACTIVITY<br>STREET WITH PROSTITUTION<br>APARTMENT COMPLEX WITH PROSTITUTION, DRUGS AND CRIMES<br>AREA WITH DRUG ACTIVITY<br>BIKE CLUB<br>PARK THAT IS UNSAFE AT NIGHT |
| 070915 | 95 | 16 (66) | 1: CRACK, WEED, PROSTITUTION; PAST X ROAD – HEROIN<br>2: THEFT, BREAKING & ENTERING, MUGGING, WEED, DOMESTIC DISTURBANCES<br>3: DRUG HOUSES, DRUG SALES ON CORNERS, GAMBLING, RAPE – DRUG RELATED AND LOCATION BASED | GAS STATION WHERE DRUGS ARE SOLD AT NIGHT<br>STRIP BARS (AND ONE IN PARTICULAR) WHERE HEROIN IS SOLD<br>STREET SEGMENT WITH MURDERS AND MUGGINGS<br>SET OF STREETS WITH DRUG ACTIVITY AT NIGHT<br>APARTMENT COMPLEX WITH DRUG ACTIVITY<br>APARTMENTS THAT ARE SECLUDED AND THEREFORE ARE A LOCATION FOR MURDERS<br>SET OF STREET WITH HIGH CRIME<br>A PARTICULAR STREET WITH HIGH CRIME<br>APARTMENT COMPLEX WITH WEED AND HEROIN ACTIVITY<br>A STREET SEGMENT WHERE DEALERS SELL HEROIN, ECSTASY, XANEX AND WEED<br>AREA AROUND A BRIDGE WITH PROSTITUTION AND CRACK HOUSES<br>AREA WITH CRACK, HEROIN, WEED AND PROSTITUTION<br>MOTEL WHERE PROSTITUTION OCCURS FOR CRACK<br>A STREET THAT IS KNOWN AS A 'CRACK WALK OF FAME' AND A BUSH AND HOUSE WHERE THE DRUGS ARE TAKEN<br>HOUSES WHERE THERE IS DRUG ACTIVITY AND SHOOTINGS<br>APARTMENTS KNOWN FOR HIGH CRIME – ALL CRIMES<br>A SPECIFIC BUILDING IN THIS APARTMENT COMPLEX KNOWN FOR HEROIN, MURDERS, SHOOTINGS<br>AREA OF CONNECTION BETWEEN APARTMENT COMPLEXES WHERE SUSPECTS CAN ESCAPE THE POLICE<br>HOUSES WITH METH ADDICTS<br>CHECK CASHING BUSINESS WHERE DRUG ADDICTS SELL STOLEN GOODS FOR DRUG MONEY, ESPECIALLY HEROIN ADDICTS |

(*Continued*)

**Table 3.** (Continued).

| ID | SKETCH NUMBER | SVG NUMBER | SKETCH DESCRIPTIONS | SVG DESCRIPTIONS |
|---|---|---|---|---|
| 072315 | 3 | 9 (33) | DRUG ACTIVITY (METH LABS, HEROIN, DRUG DEALING)<br>BURGLARY<br>ROBBERY | A STORE WHERE DRUG DEALS OCCUR<br>AREA WITH PROSTITUTION<br>AREA WITH PROSTITUTION, DRUG DEALING, METH LABS, CRACK, HEROIN, 'YOU NAME IT, YOU WANT TO FIND IT, IT'S HERE'<br>AN AREA THAT IS DANGEROUS AT NIGHT FOR BEING RAPED; ALSO DRIVE-BY SHOOTING IN THIS AREA<br>A PROSTITUTE<br>ABANDONED FACTORIES USED BY THE HOMELESS<br>'THERE'S A LOT OF ASS WHOOPINGS ON THAT CORNER'<br>HIGH SCHOOL WHERE 'KIDS WILL WAIT FOR DRUG DEALER OUT TO THE LEFT'<br>A DRUG RUNNER |
| 101615 | 7 | 11 (31) | DRUG TRAFFICKING,<br>PROSTITUTION,<br>BURGLARY,<br>DRUG USE,<br>FIGHTS | COLLEGE HOUSING WITH DRINKING AND DRUGS<br>LOCATION WITH DRUG ACTIVITY<br>HOUSES WITH SIGNS OF METH USE<br>AREA WHERE CRACK IS AVAILABLE<br>PARK WITH DRUG USE AT NIGHT<br>STREET WITH PROSTITUTION<br>BARS AND ONE IN PARTICULAR WITH DRUGS |

## Discussion

Results from the SVGs reveal that not only do the participants' geographic contexts vary across space and over time, even in a small study area, but the contextual influences exhibit dynamism as well. There are many moving parts rather than a bounded neighborhood area serving as a container for exposures (eg drug sales, pimps) and the mitigating forces that aim to push back (eg churches, rehabilitation centers). This population of criminal ex-offenders, all recovering drug addicts, have been highly mobile in their past (renting, often not at the home address when seeking/using drugs, going in/out of rehabilitation) and still exhibit residential mobility, though less so in recovery. The extreme dynamism of their contextual influences related to the drug–crime nexus was also revealed through the SVGs. Kwan (2012b, 2013) has highlighted several examples (eg air pollution, neighborhood change) where contextual influences exhibit variability even over hours, the course of a day, etc. This study contributes an additional example with a topic that is intentionally covert and where the geographic context can be momentary and not easily foreseen. For example, the drug distribution sources change (different cities – Detroit, Cleveland, etc.; different organizations managing distribution), as do the drugs of choice (from prescribed opioids to heroin) to the exact composition of the drugs (eg introduction of fentanyl, carfentanil, etc.), to police interventions, all of which change the geographic context of drug-seeking behavior at multiple scales. Unlike previous areas of study that reveal the dynamism of geographic context, the drug–crime nexus changes fast, often violently, and is covert by design. It also is a major contributor to some of the most pressing and entrenched social, economic and public health problems in the United States. It is not well-suited to a clear, observable geographic and temporal extent, and therefore existing geospatial methods are incomplete in producing actionable knowledge to inform intervention.

This study suggests that SVGs may offer a contribution to advancing understanding of the geographic context of this problem. Specifically, this paper examined results from two methods for identifying geographic context: sketch maps and SVGs. It was reassuring to find that one area (C and A in Figures 1 and 3, respectively) was consistently identified in both the aggregate sketch maps and SVG maps (Figure 4); it was also revealed through the spatial filter analysis of calls for service. This suggests that, perhaps for the highest crime areas, there is general spatial consensus across traditional and nontraditional forms of data collection. However, while there is some spatial agreement, there is considerable variation in *what* is conveyed. In addition to different characteristics reported within the SVGs, in the sketch maps it became evident that some detail is lost in the translation from their mind to the map. For example:

> "can I say like beatings? Like when the guy beat the guy with the hammer in the face…" and then "…ah prostitution, I don't spell good… and that's it, now there's a girl that has AIDS and she spreads that around over here… so I'm going to say prostitution."

None of this detail was provided on the sketch map, only in her/his audio of that process. This does not mean we should abandon the use of sketch maps, far from it. If we consider the methods for representing geographic context to be a continuum, sketch maps provide a widely accessible tool that will still enrich or complement more

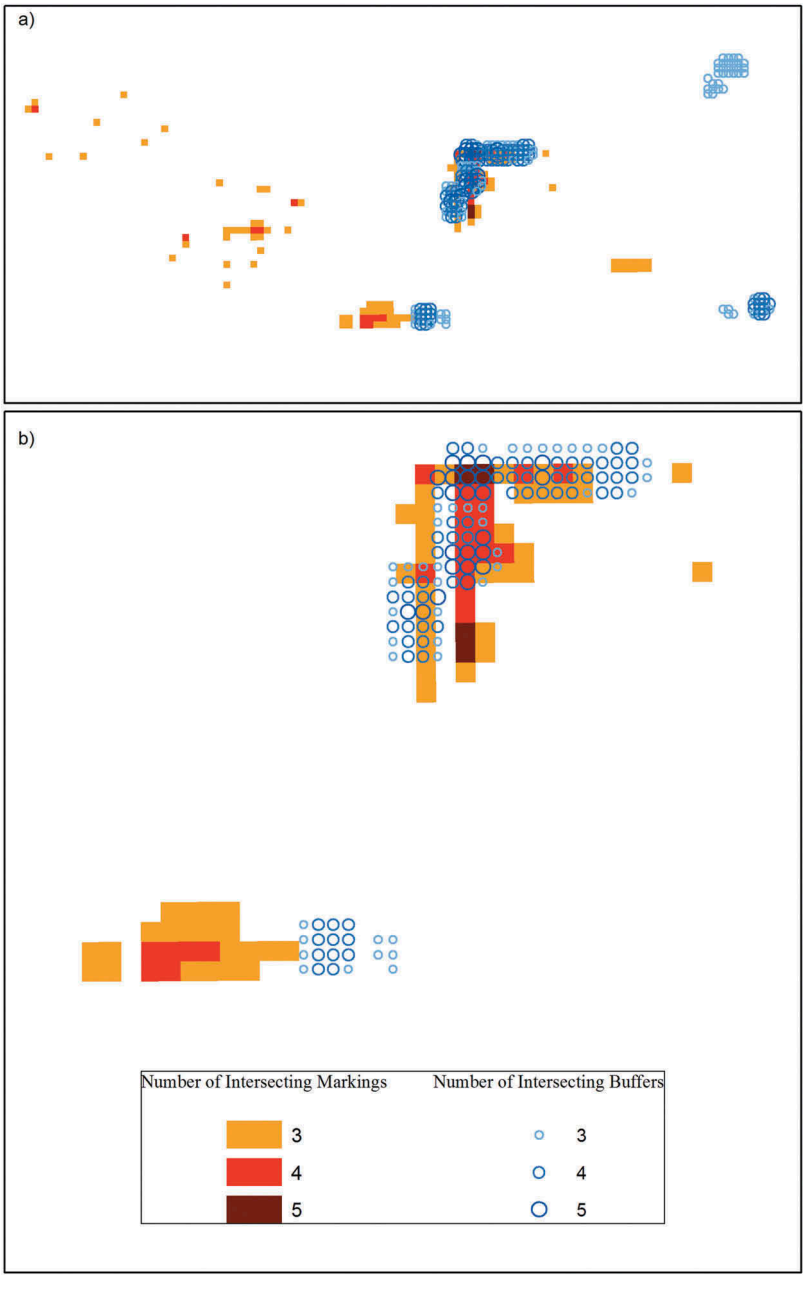


**Figure 4.** Overlay of crime hot spots from sketch maps and spatial video geonarratives: a) study area and b) zoom-in to hot spots.

traditional data. Sketch maps have low technology requirements (eg paper, markers, GIS), they can be administered relatively quickly (eg 10 min) and therefore are appropriate when obtaining the perspective of a large number of participants. Given these results, sketch mapping would benefit from thoughtful reconceptualization with a) a

dynamic base map (tablet) and b) audio recording of the narrative while sketch mapping.

By comparison, the SVG, while being more logistically intensive, identifies more spatially specific locations and with much greater depth. This result is due to some combination of reasons that should be isolated and studied individually in future research. First, it could be that the sketch maps require a level of comfort in their use, drawing upon participants' map literacy and graphicacy and therefore potentially limiting the amount and type of data acquired through this method. In contrast, SVGs do not pose such a barrier. Second, it is possible that the sketch maps primed the participants and therefore they were thinking more about the relevant issues in their neighborhood, which contributed to a more detailed narrative. Furthermore, sketch maps took considerably less time to complete, while the SVGs look longer. This difference was not an intention of the study design, but rather this is how the methods organically played out in reality. Participants usually felt that their maps were complete in about 10 min and that their SVGs had reached their end in about an hour. However, as more time was devoted to SVGs, more data could be collected. Ultimately, we suggest that the central reason for SVGs resulting in the identification of more spatially specific location and with much greater depth is because of the sensory stimulation. It triggers not only more spaces, but also places that facilitate or mitigate exposures (such as a check cashing store or rehabilitation center), and it also reveals spatial interconnections and processes over space and time. In other words, it is a more evolved geographic context. For example, we can use the SVG to help explain why areas B, D and F in Figure 2 were not identified through the sketch map or calls for service data. In the case of the sketch maps, these areas were literally outside the map provided to the participants. In almost all the SVGs, the police are described as not to be trusted and that there is a code on the street for not reporting events, especially in the highest crime areas of the neighborhood. There are also streets identified that the participants claim are police no-go areas. As a result, the 911 calls for service data are likely to contain geographic data gaps where only the most severe situation generates a data point. The ex-offender SVG not only gives us more contextual data, but also can fill in some of these data gaps left by official sources.

We will now consider the conveyed structure of the SVG before delving deeper into how environmental stimuli affect the contextual map.[7] From a purely space-time perspective, the neighborhood is no longer seen as one space but rather as nested, with varying degrees of detail based on what is seen and the past experiences of the participant in specific places. While there may be general consensus among the participants about area A in Figure 2, the experiences within and therefore the specific locations identified vary. Interestingly, the SVG 'cruise' also mimics the typical activity for many within the neighborhood – the participant knows where to go generally and then lets various cues refine the search. For this study, it included going to a known area (A) and then describing houses/bars/corners, etc. For a drug seeker, it would also include going to a known street and then refining the search based on visual cues. It should also be noted that the space within the various layers of the nest is also complex, especially in terms of heterogeneity. A road may contain both 'bad' and 'good' exposures, sometimes being located next to each other.[8] This level of fine scale heterogeneity is challenging to replicate on a sketch map.

A contributing factor within these nests is spatial interconnections, such as the alley behind, the proximate public housing and the lack of a fence, all of which make that

location problematic, and therefore to reduce the location to a single point would be missing the importance of spatial setting. Similarly, that geographic setting also has a temporal dimension: the changing nature of a park at night, the danger around a corner store during the evening hours or the changing activity along a road across the course of a day. There are even changes with seasons, or more importantly as temperatures increase, so the activity around corner stores, bars and even on front porches increases and can lead to more violence. This appreciation of time largely goes unacknowledged on the sketch map unless specifically requested. There is also a personal time continuum where experiences of one location will shift fluidly between the now, recent and distant pasts. From a GIScience perspective, this leads to the question of how to identify and then record such temporal mixing in the attribute table. This can include temporal uncertainty in terms of the participant being away (in prison) and therefore not being sure whether the described location still holds the same relevance.[9] Even more challenging is how a single space can also contain multiple memories; a street is described as being happy (maybe from childhood), but specific events (murder) and locations (drug houses) caused a decline, and then more recently, the situation has improved, especially in comparison with other neighboring streets.[10]

What is core to all these descriptions, and what ultimately differentiates the SVG from the sketch map, is the environmental cue. While the criminal experience of the participants varied, a connecting factor was drug addiction. Where to find drugs, how to acquire money to purchase drugs (eg through drug selling, burglary or prostitution) and the associated acts of violence, despair and loss (especially with discussions about the impact on children), all of which were described in the SVG. Most of the stimuli on the SVG ride acted as a window into each of these. Common perception and personal experience are also more easily separated in the SVG. While participants may identify spaces on a sketch map through what they have heard or believe, the SVG is far less forgiving in terms of allowing such general observations.

There is considerable variation in terms of what is an environmental cue. The simplest cue might be a house, but the attributes observed and interpreted by the participant lead to a deepening of the description through experience of that location or street experience in general: the trash in the yard, the way two or three blinds in the window are bent back, which is a likely indication that the house is being used for drugs. These visual cues are vital in developing the context of a scene that emerges through the SVG, but cannot possibly be captured on the sketch map, at least not in any detail. For example, one participant had identified the street being driven as problematic, but seeing bullet holes deepened the story at that location, while children playing nearby extended the participant's comment, bringing in other ecological factors such as time of year.

> "… cause that corner building up here sells heroin, right here, and something happened right there at the house across the street, that white one it has bullet holes in the side window… this one that has the board on it, they used to live there, but that guy sells heroin, isn't that crazy…look at X house right here has bullet, it has little bullet holes see them. I don't think (for children this area is) safe, because anything could happen, cars could race down the street especially when the drug, gang activity starts getting bad in the summer."

This previous quote contains two further observations worthy of discussion, people as visual cues and empathy. Not only will the participant interpret the built environment but activity within (cars outside a house, the way two cars are parked in a lot, a woman walking down the street) will also lead to a spatially specific mention. Sometimes it is a person being in proximity to a known building, other times it is the reverse, a known individual (usually a sex worker) interacting with a house, car or lot. Some of these human cues are known to the participant, while others display the trappings and activities that are well *known on the street*. Interestingly, several potential crimes, such as an interaction between a sex worker and a client, or a possible drug exchange, were witnessed while conducting the SVG by the participant that would have gone unnoticed by the research team.[11]

The second observation concerns empathy. In the above quote, the participant links visual cues, with past experiences, and the presence of children playing to create a deeper context on that space. In another example, the participant was asked about a pocket park, which led to the response that it was 'safe' during the day but had heavy drug use at night. The participant went on to mention *why would any child be in there at night*, then paused and reflected, that of course there was the possibility of children finding needles the next day. Not only does the SVG reveal a deeper insight, but the participant can even make these types of connections, from his/her perspective *because* of being involved in the SVG collection.

The investigation of the SVGs has revealed several other topics requiring further investigation outside the scope of this paper. It would be interesting to look at inter-participant variation in the amount of detail described, with some commenting on every house, and even details within a house, while others were more general in their description of a space. The participants' appreciation of spatial relations also varied, for example, some would think of boundaries (usually roads), and how crimes vary spatially. It would be interesting to see how much of these variations are due to the experiences of the participant. For example, one driver for a gang/drug dealer would cover larger areas of the city and so his knowledge was more hierarchical and nested, whereas the single neighborhood drug user/sex worker had a more detailed understanding of smaller areas. That second participant would interpret micro places through the lens of a sex worker's state of mind, how she would take a client to a bush or an abandoned house, purely on the promise of drugs and/or the likelihood of not being arrested. By her own admission, the danger of these spaces did not enter her thinking. A third participant, also addicted to drugs, would use theft to fund her habit, and would stay away from abandoned houses because of the danger they posed. The SVG approach offers an interesting opportunity to begin a new line of research into how perceptual mapping variations are influenced by these types of experience.

Further research should also consider issues of spatial precision. While this has already been discussed with regard to sketch maps in terms of how different markings capture the underlying geography (Curtis *et al*. 2014), more work is needed on spatial specificity in the SVG. For example,

> like I don't know, rape and kill. They stabbed that girl in that field right over here behind that X Street express, a whole bunch of times

> see this X Street Express down here? There was a field behind it and that's where they stabbed that girl a bunch of times

Using this example, we have potential issues with where the comment should be attached to, where the Wordmapper interpolation procedure actually places the comment (a function of both the model and the route being on a road), the precision of the GPS unit and, is often the case, a distance across which the comment occurs. Similarly, the size of the area (a pocket park compared to a building) or the importance of the extended spatial setting (the contributing environment around the house) makes us question the relevance of using just a single point. To counter this, for this paper we used three buffer sizes around each spatially specific location to approximate this fuzziness. While it is possible to manually shift each comment to the exact location being described because of the simultaneously collected video, it would be more effective to develop a series of placement guidelines or even rules to facilitate a more automated mapping of SVG context.

In this paper, we only focus on spatially specific mentions in the SVG, where a sensory cue leads to context. In so doing, we miss other spatial insights contained in the fuzzy or spatially inspired comments. Examples include comparisons among areas, transition zones or boundaries based on activities that occur in these locations, or where there are concentrations of activity, such as a road known for prostitution, or where homeless camps can be found. For example, in this spatially inspired comment, there is also specific spatial detail. We should consider how we can incorporate these additional spatial data.

> " you're in that neighborhood because there's drugs in that neighborhood and you're walking down that street probably to get drugs on your way to get drugs. . .I mean you can be picked up on any street at any time, certain neighborhoods, guys will just.. you know, I get real uncomfortable on A street, there's a certain part of it, every time I walk on it, they don't just stop with no.."

While we mentioned the presence of emotion on the ride, and even empathy shown by the participant, we have not performed any sentiment analysis on these SVGs, and yet, arguably, these data are ideal for this type of research. Not only do we have a whole narrative to train our interpretation of what is transcribed, but we can also return to the audio to hear how the words are spoken. For example, one subject commented on the recall beginning to make her cry, whereas another suddenly felt uncomfortable and wanted to leave, this desire for flight triggered by the stories he was telling. These data open research avenues into how such emotions can be effectively transcribed and mapped, as well as into how to recognize linguistic constructs that are indicative of an emotional type, including sarcasm.

In terms of what these contextual insights mean for crime analysis, the mixing of various crime types within the same space suggests that there is a danger in focusing on a single crime type – these are multi-risk environments and should be treated as such. As an illustration of this, although drugs are mentioned on all but one of the sketch maps, there is no indication from the way the participants mark the maps that drugs are an integral force in this neighborhood – they appear consistently, but so do other crimes listed (eg prostitution, various forms of assault). The SVGs make clear that the crimes and conditions in the built and social environment are driven by drugs. This result indicates the value of being embedded in place with participants so that the environment can cue their insights.

## Notes

1. See Kwan and Ding (2008) for a thorough literature review on narrative analysis.
2. While gaining the perspective and insights of those who best understand an area or topical situation has many benefits, it should also be noted that there are dangers that must be considered with regard to the welfare of the participant and those being discussed. The SVG can cause emotion in the subject, and while the team discussed both before and during the ride that the participant could end the SVG at any point, we must also be mindful of causing any emotional trauma. This will vary in every situation, but during the rides described in this paper, no participant ever described anything other than an unease – not because of an immediate threat but because of what a space had meant to that person in the past. Even so, embeddedness is not always desirable or even possible, which raises the need for investigation of Virtual Reality (VR) or other forms of simulation as an alternative approach in this line of research. We must also be aware of any stigma that can be attached to a person, building or neighborhood in general through this work. To counter this, no individuals have been mentioned, nor any places identified on a map. Even the neighborhood being described and mapped has been removed. As use of geographically embedded approaches grows, inquiry should also expand to focus on the numerous ethical considerations that arise in order to provide guidance to protect our participants while making the best use of their valuable local knowledge.
3. Wordmapper, developed by A. Curtis and Ajayakumar at Kent State University, was designed to provide mapping capability of the transcribed text for experienced spatial users (GIS output), spatial novices (Google Earth output) and researchers wanting to perform qualitative analysis (Comma Separated Value (CSV) output). Wordmapper, a Python-based stand-alone software, has five modules including preprocessing, combination, visualization, query and output. The preprocessing module accepts the narrative in the form of transcribed text, GPS data in the form of Comma Separated Value (CSV) file and offset time to synchronize between the temporal information in the narrative and GPS data. The preprocessing module also validates all data inputs. The combiner module syncs the narrative with the GPS data based on timestamps to create tuples of narrative texts of the form <sentence,timestamp,coordinates>. Apart from mapping the narrative and the GPS data, the combiner module also extracts words from sentences and assigns coordinates to each of them. The words are extracted using the tokenizer module from the Natural Language Toolkit (NLTK) module in Python. Each word of the form <text, time> is converted to a triplet of the from <text,time,coordinates> using a linear interpolation algorithm. The visualization module in Wordmapper receives processed geonarratives from the combiner module and utilizes Google Maps API and keyword-based wordclouds to visualize the data. Output from Wordmapper includes interactive mapping of words, comments and keyword queries, either in the onscreen map or as KML or shapefile outputs.
4. Even though KDE is a useful technique for visualization, in typical application it is not a statistically rigorous analytical tool (Curtis *et al*. 2010). To improve statistical rigor, the Spatial Filter module utilizes a variant of spatial filtering developed by Rushton and Lolonis and mainly used in epidemiological studies (Rushton and Lolonis 1998, Rushton *et al*. 2004). A grid is imposed over the study area, and a filter (circle) with an input adjustable bandwidth is placed on every grid node. At each grid node, rates are calculated using numerator (eg wordmapper keywords) and denominator (total words). The locations of numerator and denominator points create a smooth surface rather than one truncated by political boundaries. With a larger bandwidth, more points are included in the rate calculation, and the final surface tends to be smoother. Spatial filter output consists of a grid with a rate calculation attached to each node. A Monte Carlo simulation is used as a proxy for a statistical significance test. Synthetic numerator sets are created from the denominator sets, and rates are calculated at each node for each simulated surface. Based on the number of simulations, typically 99,999, and 9999, the *p*-values can be

calculated for each grid based on the following formula (Supplementary Material – Appendix B). As the method can be computationally expensive based on the granularity of the grid and the extent of the study area, we have developed a stand-alone spatial filter application using Python, which utilizes a spatial k-d tree for neighbor-based searches and eliminates grids without neighbors for simulations.

5. Note that in small areas where many spatially specific comments were made, the individual buffers of such comments are merged.
6. Individual sketch map locations of high crime, along with SVG paths and locations of high crime, are provided in Supplementary Material – Appendix C.
7. We have purposefully stayed away from crime theory in this paper. However, the detail in the SVG also has value in terms of supporting various theories and debates in the criminology literature. For example, the narratives are full of 'broken windows'-style descriptions, usually in terms of explaining why blighted and rundown properties act as an attractor for crime, but also as a precursor to other activity: a visual cue that the street is sliding downward. Connected to this, the SVG frequently mentions the importance of neighborhood oversight, which is a key component of routine activity theory.

*'I think that abandoned houses are pretty scary, the more you have in a neighborhood the more activity you are going to… It's about the neighborhood and who lives by it, you got a house like this where they take care of their yard and they got a fence, a lot of times they are going to pay attention and they are going to call the cops so somebody might avoid that, so that you know, the cops just come in there and arrest them.'*

Interestingly, this subject then went on to describe how visible presence shouldn't fool you as many drug dealers live in the nicer homes so as not to draw attention to themselves (or even in completely different and better neighborhoods) and deal from cars or 'trap houses'.

8. Again, the value of the SVG is that it can offer explanations to this heterogeneity. For example, locating a drug operation near a sanctuary house is attractive to some dealers as they know there is a desperate clientele trying hard not to relapse. *'..this is the (a sanctuary house), there is a dope house, and right there on the left. There is a dope house right here on the left, two doors down.'*
9. While not described in this paper, the SVGs contain multiple references to the fluidity of crime in the neighborhood, in terms of how people seek (eg drugs), how drug houses change, how drug organizations reorder themselves spatially and the difference between the home and activity space (for professional drug dealers).
10. All our participants displayed examples of this movement between the present and the past. It would be interesting to investigate how much of this mixing also influences the sketch maps.
11. This is a difference with the seminal work of Sampson and Raudenbush (1999) who had commented that it was unlikely to ever witness an actual criminal event happening. These SVG reveal that many such events occur on every ride if there is an expert who can interpret the environment.

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