Emotional Cartography:
Mapping Feelings of Anxiety Across Urban Space in London, UK

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I. INTRODUCTION

One's experience of inhabiting space in cities is unique and subjective. The meaning, memories, and emotions that we attach to our surroundings impact the ways that we engage and interact with them. While these elements of our urban lives are often unconscious and thus challenging to convey, they are a fundamental part of our daily experiences in cities.

GIS, as both a technology and a science, has enabled much research on the ways that we inhabit space in cities. Newly available geographic data, such as that from social media or mobile devices, has allowed GIS practitioners to gain valuable insight into city-wide phenomena (eg. Vanky et al., 2017; Zhou and Zhang, 2016). However, efforts to use GIS to represent data that is focused on people, at an individual and human level, remain challenging (Lü et al., 2019, p. 350).

Consideration for this shortcoming requires one to think critically about how GIS is used to understand and represent space. Scholars have critiqued GIS for its often positivist approach to representing space and prioritization of objective spatial knowledge (Schuurman, 2000; Schuurman and Pratt, 2002). Feminist GIS has emerged to address these critiques, demonstrating how GIS can be used to investigate individual lived experiences and consider both quantitative and qualitative spatial knowledge (Kwan, 2002; McLafferty, 2002).

In this paper, I investigate the following research question: *How do my feelings of anxiety change as I move through space in London?* I aim to apply theories from feminist GIS to demonstrate how subjective, personal data can be represented cartographically to reveal insight into my experience of inhabiting a city. I demonstrate how open-source GIS tools can be applied to create an interactive visualization that conveys a form of subjective spatial knowledge. This work addresses the need to consider not just the aggregated and objective elements of people's urban lives, but also those that are individual and subjective.

II. LITERATURE REVIEW

As has been reviewed by Schuurman (2000) and Schuurman and Pratt (2002), many scholars have critiqued GIS for its focus on positivist, scientific, and objective ways of knowing. Traditionally, GIS has dealt with quantitative data at larger scales and is based on a Euclidean understanding of space (McLafferty, 2002). GIS, as such, is not well-suited to represent individual bodies, situated knowledge, or the complex interactions between an individual and the space around them (Kwan, 2002). Existing representational geometries in GIS, such as points and lines, are insufficient in fully capturing qualitative elements of an individual's experience in space (Kwan, 2002) and can detach the researcher from the research subjects (McLafferty, 2002).

Efforts to combine GIS with approaches in feminist geography have emerged to address such critiques and limitations. This work demonstrates how GIS can be used in feminist geographic research to counter traditional aggregate approaches to analysis and direct attention towards individual lived experiences (Kwan, 2002). Taking a feminist approach to GIS can also allow researchers to engage with new forms of geographic data, such as sketch maps, photos, and

narratives (McLafferty, 2002). While the literature does not offer a clearly-defined methodology for 'doing' feminist GIS, common elements include the integration of qualitative and quantitative data, sensitivity to subjective spatial knowledge, empowerment of research subjects, and iterative and reflexive approaches to analysis (Gilbert and Masucci, 2006; Knigge and Cope, 2006; Kwan, 2002; McLafferty, 2002; Pavlovskaya and Martin, 2007).

Much work in feminist GIS has focused on cartographic visualization as a method of data exploration and analysis. The map interface is useful as it can integrate qualitative and quantitative geographic data by location and provides useful information on geographical context (McLafferty, 2002). In this domain, cartographic approaches have been applied to understand Iranian women's use of public space in Tehran (Bagheri, 2014), Muslim women's movement in Ohio post 9/11 (Kwan and Ding, 2008), and citizens' emotions towards places of cultural heritage in Korea (Jang, 2012). These examples demonstrate how cartography is an appropriate tool for gaining a stronger understanding of the lived experiences of individuals in space.

III. METHODOLOGY

QGIS and R were used for the technical elements of this methodology. Links to a repository of code and data, and a detailed tutorial can be found in the Appendix of this document.

i. Data Collection

I collected qualitative and quantitative data to capture my feelings of anxiety while moving through London. Firstly, I used a wearable fitness monitor (in this case, a Fitbit Charge 2 device) to collect data on my heart rate in both space and time. This data consisted of a series of points, sampled every 1-5 seconds, that contained my coordinate position, timestamp, and heart rate value. Throughout this project, I use heart rate as a proxy for anxiety levels, assuming that an increased heart rate corresponds to an increased level of anxiety. Secondly, I collected qualitative data on my emotional reaction to my surroundings (hereafter referred to as 'personal comments'). I recorded this qualitative data using the VoiceRecorder iPhone app, which also recorded the time of each personal comment. I collected these comments to provide additional context to my heart rate data, and to potentially explain some of the variations in my heart rate.

I collected both types of data over a period of two weeks in London. Given that my aim is to investigate changes in anxiety through space, I only collected data while I was physically moving. To ensure that my heart rate was relatively unimpacted by varying levels of physical exertion, I also only collected data while I was walking. Given that I wanted to capture an element of my daily experiences in the city, I went about my normal activity patterns while collecting data.

ii. Data Cleaning and Processing

Heart rate, coordinate, and timestamp data was exported from the Fitbit device in .TCX format, with one file for each walking route. I merged all files, removed unnecessary variables, and projected the geographic data to WGS84 (EPSG 4326). This processing was conducted in R.

Following Jang (2012), I used inverse distance weighting to interpolate my point-based heart rate data to create a continuous layer of my anxiety levels. To smooth the layer in areas with many measurements, I applied the SAGA Gaussian filtering tool in QGIS ("Module Gaussian Filter / SAGA-GIS Module Library Documentation (v2.3.0)," n.d.). I created a buffer 10 meters around all heart rate points and used this polygon to define the spatial boundary of my heart rate layer. I created a buffer of this size to acknowledge the fact that my anxiety in a given location can be impacted by various elements of the surrounding region, and is thus not just the product of a single point. These processing steps were conducted in QGIS and are summarized by the flowchart in Figure 1, below.

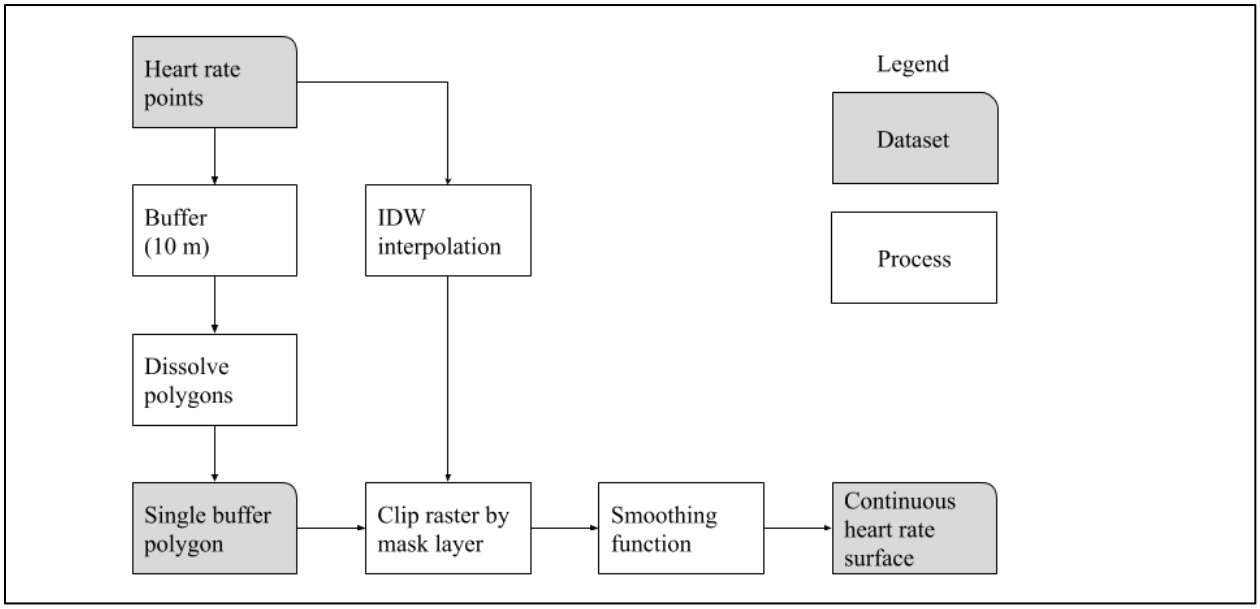


Figure 1. Workflow of data processing conducted in QGIS

I manually transcribed all personal comments and stored them in a file with the date and time of each recording. The geographic location of each comment was determined by matching it with the coordinates of the heart rate point with the nearest timestamp. Given the differing temporal resolution between the comments and the heart rate data (to the minute and to the second, respectively), there is the potential for slight inaccuracy in the geolocation of each comment.

iii. Coding of Personal Comments

I manually coded the content in each personal comment according to both its theme and direction of impact on anxiety (with positive corresponding to less anxiety and negative corresponding to more anxiety). This analysis was done to more directly link this qualitative data to the context of my research, identify patterns or recurring themes in the comments, and provide a condensed version of the raw text (Saldana, 2015; Thomas, 2006). I took an inductive approach to coding each personal comment according to theme (Thomas, 2006). I read through all notes and recorded, in one word, the primary theme that emerged from each note. I then grouped together similar themes and identified the higher-level theme for each of these groups. To code the

comments according to direction of impact on anxiety, I interpreted each comment then classified its overall sentiment as positive or negative.

iv. Exploration and Visualization

I first explored the basic characteristics of both datasets through summary statistics and visualization.

Both the heart rate and personal comment data were then visualized in an interactive, web environment using the Leaflet package in R. Interactive visualization was chosen to allow for an iterative, exploratory approach to investigating the data (Knigge and Cope, 2006) and for more effective integration of qualitative data (MacEachren and Taylor, 1994). I overlaid the heart rate layer on top of a basemap of satellite imagery and used a continuous colour scale to reflect changes in heart rate values. Given the difficulty in adding text data directly on a map, I added a point for each personal comment that was coloured according to its direction of impact on my anxiety. The full text data and qualitative codes of each personal comment could be accessed by clicking on each point and viewing a popup.

IV. RESULTS

i. Summarizing the Data

Data was collected between December 4, 2019 to December 14, 2019 from a total of 15 distinct trips. During this period, 36 personal comments and 17,068 heart rate point measurements were collected. Heart rate values ranged from 84-184 beats per minute. As shown by Figure 2, this data appears to be normally distributed, with a mean of 123 beats per minute and standard deviation of 12.

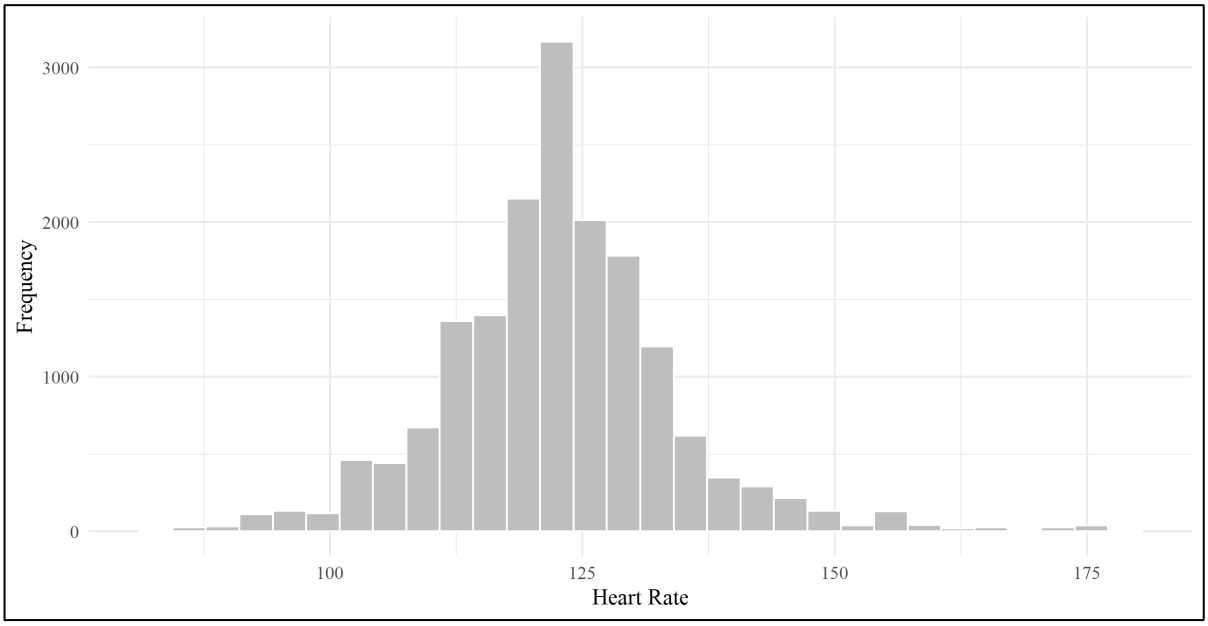


Figure 2. Histogram of heart rate values

Figure 3 illustrates the uneven spatial distribution of these heart rate measurements, reflecting my own uneven patterns of movement within the city during this time period. This figure shows a notable concentration of measurements along a band towards the centre of the study area.

Of the 36 personal comments that I recorded, 21 are coded as having negative impact on anxiety levels and 15 are coded as positive. The following seven themes were identified in the coding process: ‘visuals’, ‘traffic’, ‘people’, ‘noise’, ‘nature’, ‘danger’, and ‘other’. Figure 4, below, shows the frequency of occurrence for each theme, broken down by direction of impact on anxiety. Comments relating to both ‘visuals’ and ‘nature’ had solely positive impacts on my anxiety levels, while themes such as ‘traffic’, ‘people’ and ‘danger’ were predominantly negative. Most comments (12) were coded with the ‘traffic’ theme.

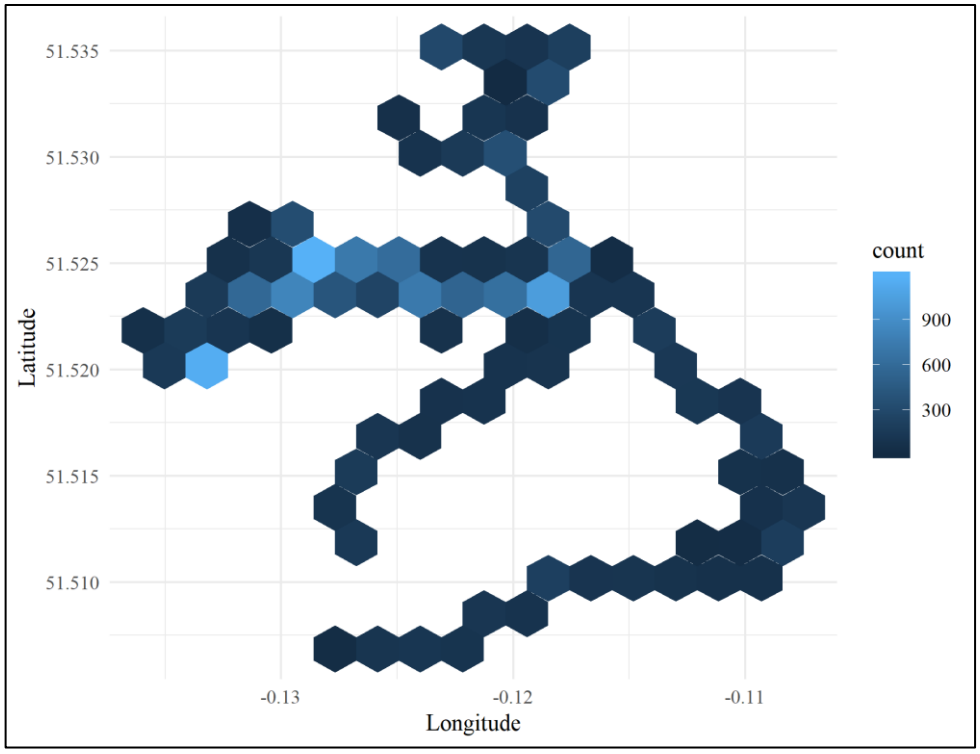


Figure 3. Hexbin plot of spatial distribution of heart rate measurements. Bins with lighter colours contain more data points.

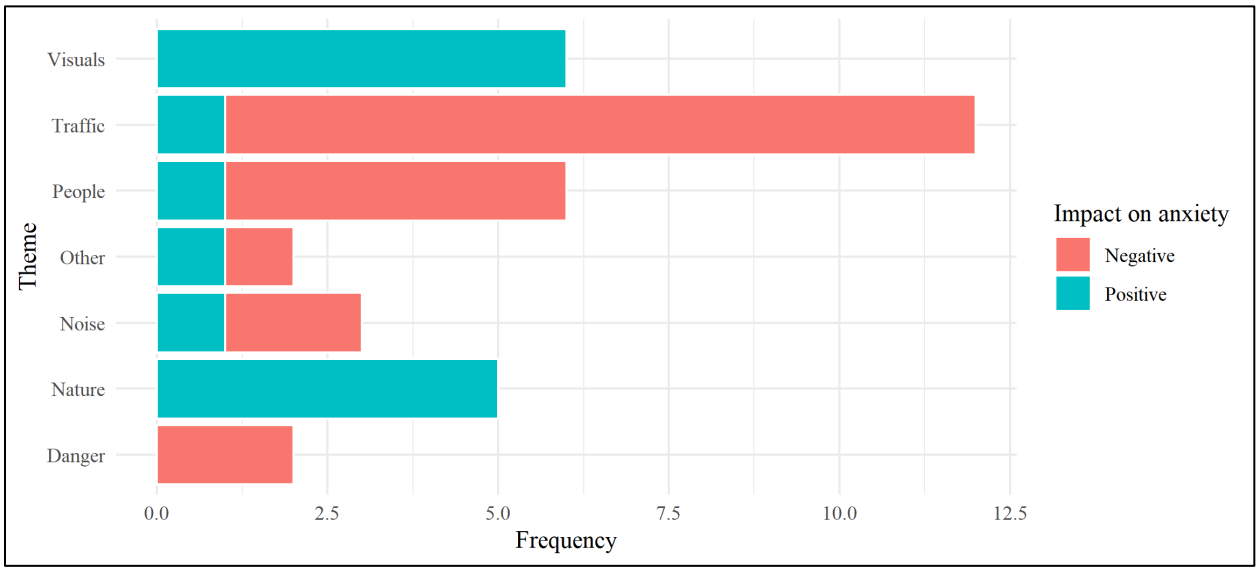


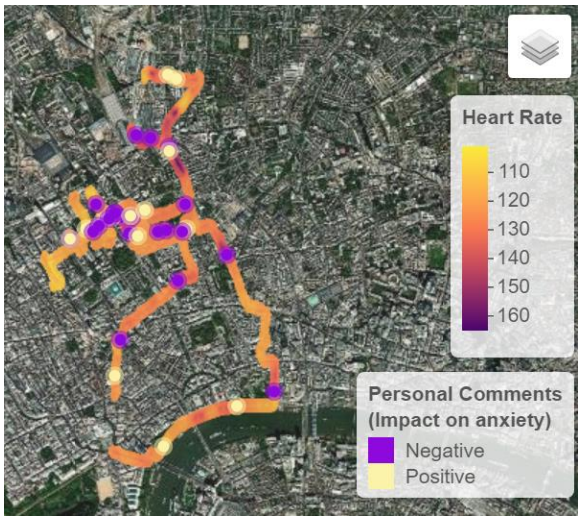
Figure 4. Bar chart showing frequency of occurrence of personal comment themes, broken down by direction of impact on anxiety.

ii. Examining changes in anxiety in London

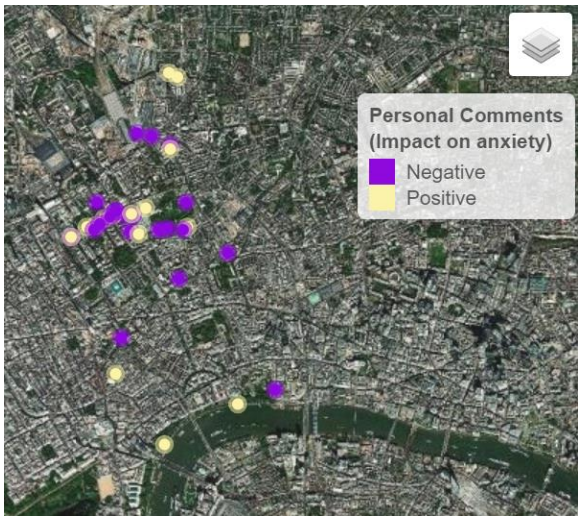
Figure 5 shows a series of screenshots from the interactive Leaflet map that integrates both the heart rate data (in the form of an interpolated raster layer) and personal comments (as clickable points). Figure 5 demonstrates how this interactive map can take a number of forms as the user interacts with the data in different ways. To engage with this map in its intended format, visit the link attached in the Appendix of this document.

The total study area covered by this map encompasses a region within downtown London that is located primarily within the Camden borough. This map shows that my anxiety levels appear to be relatively stable in the area centered around UCL campus and my residence. This area also has the most complete coverage of the anxiety layer, likely due to more frequent movement in this region. My anxiety levels fluctuate most notably in the northernmost region of the map, near King's Cross Station and Regent's Canal. A sustained peak in anxiety can be seen on one of the streets leading up to King's Cross Station. This peak is accompanied by both a positive and a negative personal comment, relating to the visual appeal of restaurants and an encounter with another individual, respectively.

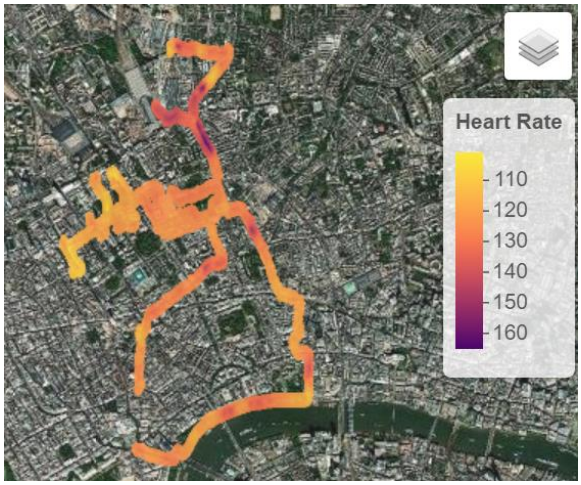
There does not appear to be any notable clustering of negative or positive comments. However, one road section has many more comments than others, perhaps due to more frequent movement in this area. My heart rate appears to be relatively normal along this road and the personal comments indicate that my emotional experience was positively impacted by the presence of a number of parks that I walked by, and negatively impacted by crowded sidewalks and complex street intersections.



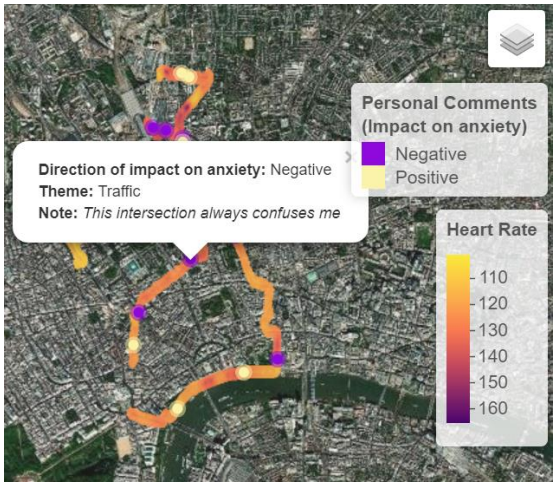
a) Both map layers selected



b) Only personal comments layer selected



c) Only heart rate layer selected



d) Personal comment popup selected

Figure 5. Series of screenshots from the Leaflet map, demonstrating various possibilities for viewing the data

V. DISCUSSION

i. Reflection on research findings

My research findings demonstrate how my levels of anxiety change in complex ways as I move through space in London. As has been demonstrated in other feminist GIS projects (eg. Knigge and Cope, 2006), the combination of qualitative and quantitative data has resulted in a rich representation of space. An integrated exploration of my heart rate and personal comments suggests that my interactions with entities such as cars, people, and parks have an impact on changes in my anxiety levels. Overall, it appears as though my levels of anxiety are most stable areas within the city where I have travelled more frequently (indicated by more frequent

sampling of heart rate measurements). I experience greater fluctuations in anxiety when I travel to places that I am less familiar with.

Despite these insights, my findings are deliberately ungeneralizable and inconclusive. I do not suggest that my emotional experience is shared by others, nor do I make a rigorous attempt to identify the factors that contribute to the changes in my emotional state. By constraining the ambitions of this research effort in such a way, I acknowledge that there are many different, subjective ways of experiencing space. This approach reflects the feminist perspective on GIS that seeks to accommodate many possible truths about a given space and acknowledges many potential interpretations of a given dataset (Knigge and Cope, 2006; McLafferty, 2002). Through the interactive elements of my visualization, I encourage the map viewer to play an active role in interpreting my personal data.

It is of course important to acknowledge potential issues with the validity of my approach to measuring anxiety. My heart rate is an imperfect proxy for anxiety levels and the binary distinction between positive and negative impact on anxiety in my personal comments may be reductive. As such, the findings in this study have a degree of uncertainty and error.

ii. Cartographic challenges and limitations

There are a number of challenges associated with representing subjective, emotional, spatial data that should be reflected upon. Firstly, GIS does not have a well-established representational framework for emotional data. The many dimensions and fuzzy spatial boundaries of emotions such as anxiety cannot be simply visualized using points, lines, or polygons. While the raster data type can effectively visualize changes in continuous values over space, the spatial boundaries that I have chosen for this layer are somewhat arbitrary.

My choice to present this data on top of a basemap of satellite imagery also suggests a sense of objectivity and rationality of space that may be incongruous with the highly subjective nature of the data that I am presenting. I chose to add a basemap to provide basic geographic context to my data, but acknowledge that other cartographic approaches, such as sketch maps (eg. Boschmann and Cubbon, 2014), may be more appropriate in presenting subjective, non-Euclidean space. However, the often-analog nature of sketch maps makes them challenging to incorporate in a web-based environment and overlay with multiple data layers.

For conceptual simplicity and ease of visualization, I also chose to disregard the temporal dimension of my data. However, this choice may limit the accuracy of my findings as emotions such as anxiety vary across both space *and* time. For example, many of the personal comments related to ephemeral entities, such as passing sirens and crowds. While past work has adapted theories from time geography (Hägerstrand, 1970) to visualize individual experiences in space and time (Kwan, 1999a, 1999b), this approach is limited in its capacity for interactivity and does not allow for the inclusion of point-based qualitative data.

As I explored a variety of avenues for addressing these challenges and effectively presenting my data, my map-making process involved many iterative steps of testing different tools and visualization parameters. This nonlinear approach to data exploration and presentation is aligned

with past feminist GIS approaches (eg. Knigge and Cope, 2006) and allowed me to gain a greater intuition of my data, leading to a richer interpretation. The cartographic challenges that I faced also point to the need for GIS practitioners to acknowledge the ways that our representational tools and frameworks constrain how we present, and subsequently interpret and understand, spatial data.

VI. CONCLUSION

Guided by a feminist approach to GIS, I have explored changes to my feelings of anxiety while moving through space in London. My findings suggest that my levels of anxiety are more stable when in familiar places and more variable when in unfamiliar places. A variety of urban elements; such as other people, cars, intersections, and natural features; appear to have an impact on my levels of anxiety.

One of the primary contributions of this study is my demonstration of how open-source GIS tools can be used to integrate qualitative and quantitative data to represent a personal, emotional experience in space. This work is intended to compliment the current stream of urban analytics work that is largely quantitative, aggregated, and large scale. I have addressed a number of cartographic challenges and have attempted to further develop techniques for using GIS to analyze and represent subjective spatial data relating to personal experiences in cities.

VII. APPENDIX

Online repository with full code, QGIS processing model, datasets, and procedural walkthrough: https://github.com/hannahker/CASA0005-final

Tutorial document: https://hannahker.github.io/tutorial-bookdown/

Interactive Leaflet map: https://hannahker.github.io/CASA0005-final/output_leaflet.html

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