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Willis, KS

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Research Article

Sense and the city: An Emotion Data Framework for smart city governance

Katharine S. Willis^{a,*}, Christian Nold^b^a School of Art, Design and Architecture (Faculty of Arts, Humanities and Business), Roland Levinsky Building, Drake Circus, Plymouth, Devon, PL4 8AA, United Kingdom^b Design Group, School of Engineering & Innovation, The Open University, United Kingdom

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ABSTRACT

In the smart city agenda, data plays a key role in shaping governance and participation around urban planning, and this data is increasingly derived from sensors of all kinds. These sensors increasingly include physiological and sentiment analysis to gauge the emotional states of urban citizens. In urban planning, emotional data has so far been conceptualised as ‘people as sensors’ where data is used to create an aggregated emotion layer for real-time urban planning. This paper argues this approach does not enable citizens any meaningful participation in urban planning. In contrast, this paper demonstrates what emotion can ‘do’ when citizen actively use emotions to participate in the problem framing in smart city governance. The paper offers a framework of smart city participation with emotion data by focusing on the Bio Mapping project, where physiological sensors are used as participatory mapping approach that led to urban planning. This approach enabled citizens to engage in a dialogue around their emotional response to urban space and articulate the potential for emotion data in urban governance. There needs to be a consideration of 1) multi-dimensional emotion data, 2) an active participant role, 3) extended participation within the planning process 4), and empowerment within urban governance. The paper argues that a participatory approach to emotion data can function as a dynamic leverage point of negotiation in smart city governance between citizens, urban space, and civic agencies.

1. Introduction

1.1. Emotion data and smart cities

This paper explores the role that emotion data — meaning physiological body data that can be captured of people's sensations as well as their stated feelings — can and should play as part of the governance of smart cities (Fathullah & Willis, 2018; Nold, 2009). In the concept of the smart city, heterogenous forms of data are envisioned to play a key role in shaping governance and participation (Batty, 2013; Cardullo & Kitchin, 2018). For many of the visionaries of smart cities, citizen opinions, sensations and feeling play a key part of creating a ‘sentient city’ (Crang & Graham, 2007; Shepard, 2011), “where we not only think of cities, but cities think of us, where the environment reflexively monitors our behaviour” (Crang & Graham, 2007). Yet the specific role that citizen emotion data should play and how it can be integrated with established urban planning processes is less clearly articulated. This paper addresses this gap by analysing

* Corresponding author.

E-mail address: katharine.willis@plymouth.ac.uk (K.S. Willis).<https://doi.org/10.1016/j.jum.2022.05.009>

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the way emotion data has been used in relation to decision-making processes around smart cities by carrying out a review of the urban planning and interaction design literatures. The research question we address is - what should be the role of emotional data in empowering citizen participation in smart city governance? The paper uses the widely recognised Arnstein's Ladder of Participation (1969) to produce one of the first comprehensive mappings of emotion data projects and analyses them in relation to Arnstein's categories of participation. To contextualise this analysis with a real-world example, we introduce a case study of an emotional mapping project undertaken by Nold in Bethlehem, USA (Coombe, 2009), that successfully used collaboratively gathered Galvanic Skin Response (GSR) data to inform urban planning decision making in the city. Drawing on this case study, we offer a novel 'Emotional Data Framework' and argues for the need to use participatory approaches to urban data that involve reflective dialogue and collaborative analysis rather than extractive emotion data gathering. The paper proposes that there is yet untapped potential for emotion data to take a substantial and transformative role in smart city governance.

1.2. The emotional layer of the smart city: humans as sensors

Cities have always been understood as eliciting emotional experiences; as described in the field of urban phenomenology (Pallasmaa, 2012), but the development of an 'emotional layer' of the city goes further by proposing that there is a stable and measurable relationship between citizens emotional state and the physical features and characteristics of the city. Whilst some of this work precedes the smart cities developments, it takes an approach that aligns directly with the model of real-time data gathering that characterises smart city projects. For example, social media sentiment analysis has been used gather users' wellbeing and feelings and to map them to geographic location (Mislove et al., 2010, Mackerron & Mourato, 2013), and studies around cities and wellbeing focus on 'Happy City' (Montgomery, 2015) or 'City Love' (Kourtit et al., 2021) to determine the urban characteristics of place attachment and appreciation and have been tested in European and American cities.

Recent developments in AI sentiment analysis and the widespread use of social media mean that emotion data is increasingly seen as another data source in the smart city. In this model, citizens are not just participating in gathering or accessing data but are in fact the source of the data; they are the sensors. This is referred to in the literature as 'humans as sensors' (Resch, 2013b), which references a 2007 paper by Goodchild where he outlined the concept of "citizens as voluntary sensors" (2007), and includes human sensors (Zeile et al., 2015), citizens as sensors (Goodchild, 2007) and social sensor networks (Sagl et al., 2012). According to Resch et al. 'people as sensors' represents a model in which not only digital devices produce data sets, but where subjective measurements are generated by people so that these "human sensors' can supplement or sometimes replace expensive and specialized sensor technology and sensor networks" (Resch, Summa, et al., 2015). The types of data that inform this approach to the city has been referred to as the 'emotional layer' (Zeile et al., 2015), and refers to the sensation and emotion of the sentient city and includes physiological body state derived from wearable devices, self-reported feedback, as well as semantic data scraped from social media feeds such as Twitter or Instagram.

In this approach individuals are attached to measurement systems which are aggregated to form a kind of human sensor network for data in the city (Littlefield, 2021). The differentiating factor between sentiment data and emotion data is the mode of data gathering. Typically, emotion data is gathered through some form of biometric device such as a GSR or Electroencephalogram (EEG). GSR refers to a method that measures a form of electrodermal activity (Dawson et al., 2007) and typically, this involves the person wearing a small strap sensor on the fingers of the hand. GSR is said to "indicate effective correlation to [emotional] arousal" (Kim et al., 2010) which can be correlated to stress levels. GSR is a useful measure of emotional response as it can "detect a very sensitive amount of arousal" (Kim et al., 2010) and has been used by researchers to assess participants' emotional response to gain insights into people's emotional response to urban environments. The Urban Emotions Lab are a key proponent of this approach using it to measure and 'ground-truth' emotion in relation to a number of categories of emotion and combining it with other crowdsourced social media data (Zeile et al., 2015). This approach takes physiological or biometric data from the individual and links it to the physical location in the city to create an aggregated 'emotion layer' of response to the characteristics or features of the urban space.

1.3. Research problem

The issue we seek to highlight with emotional data extraction in the 'humans as sensors' approach is that it privileges what Cardullo and Kitchin refer to as algorithm decision-making over "political discussion and agonist processes of governance" (Cardullo & Kitchin, 2018). The emotional layer approach negates subjective nuance and difference in emotional response between different people and communities in an attempt to create a universal interoperable layer. We argue that this approach is fundamentally flawed as a tool for inclusive urban governance (Nold, 2018) and there is a need to develop other participatory approaches, where people are not just providing data, but also in analysing it and involved in decision making around the aggregated results.

2. Literature review: participatory data and smart urban governance

2.1. Smart citizens, sensors and participatory data

There is an extensive body of literature that has examined the rhetoric around smart citizens and the role they play in shaping the smart city (Cardullo et al., 2019; Datta, 2018, March & Ribera-fumaz, 2014; Willis, 2019). The smart citizen approach shifts the focus from the installation and management of digital infrastructure and sensors to proactively involving people in 'bottom up' data gathering and analysis in relation to more localised issues. It is important to understand that participation in data can occur on many levels. There have been several papers that discuss whether smart city frameworks enable citizen control or whether the citizen acts tokenistically as a

data source for public sector or commercial organisations (Haklay, 2015; Shelton et al., 2015; Vanolo, 2014). Here the data is not gathered or analysed by the citizens but through their everyday use of smart city devices and technologies, they are the ‘data product’ (Cardullo & Kitchin, 2019) which can be used by commercial companies and city councils “in ways that they are unaware of and do not consent to” (Cardullo & Kitchin, 2018). According to Gabrys, the result is that “citizenship transforms into citizen sensing” because they act as “unwitting gatherers and providers of data” (Gabrys, 2014). Therefore, the nature of smart citizenship should be critically addressed in the context of what data is gathered and how citizens participate in the sensing practices.

In efforts to move beyond the role of citizens as ‘data products’ a number of initiatives have sought to address issues of citizenship by developing ‘citizen sensing’ and participatory data platforms as a means of giving more democratic and equal access to urban information (e.g. Balestrini et al., 2016; Haklay, 2015). These models of citizenship include a more diverse and inclusive group of people and are typically informed by their own local concerns, challenges or interests. They include crowdsourcing (Cowley, 2010), citizen science (Haklay, 2012), citizen sensing (Balestrini et al., 2016), hackathons (Johnson and Robinson) and living labs (Cosgrave et al., 2013). This can involve people being given small pollution sensors to carry with them as they drive or cycle around the city, and then this data being uploaded and combined with other people's data to create pollution maps of the city (e.g. the Smart Citizen Kit (Veenkamp et al., 2020)). According to the EU Citizen sense project, urban participatory citizen sensing goes beyond citizen science and instead: “enters the realm of empowerment and citizenship in the city. Collection, production and use of data become practices of engagement and action through DIY sensing technologies for environmental monitoring’ ... and it has purpose for the actors involved in these collective activities of “making data matter” (Balestrini, 2016).

Typically, citizen science and participatory smart city data has focused on environmental data and mobility data in the city. But the data is increasingly gathered not just from fixed or mobile sensors embedded within the city's technical infrastructure but from data sourced from sensors linked to people's social media feeds and wearable biometric devices.

2.2. Participatory data and smart citizenship

Smart city participation has been identified by many researchers as problematic, whilst many projects claim a participatory approach, they lack meaningful involvement of citizens (Datta, 2018; Willis, 2019). Arnstein's ‘Ladder of Participation’ (1969) has been used to analyse the ‘actually existing’ smart city (e.g. Cardullo & Kitchin, 2018; Shelton et al., 2015), since this framework provides a way to identify the “critical difference between going through the empty ritual of participation and having the real power needed to affect the outcomes of the process” (Arnstein, 1969). In Arnstein's analysis, a critical aspect of any relationship is that there is a form of a partnership with equal opportunity to contribute and participate (HUD, 1968, p. 18 cited in (Gaber, 2019)), which leads to citizen power. The ladder categorises the steps of public participation rising from manipulation, education and consultation to partnership and citizen control at the top, see Fig. 1.

In the context of the smart city, Cardullo and Kitchin interrogated a range of projects against Arnstein's model of participation and produced the ‘Scaffold of Smart Citizen Participation’ (2018). In this diagram, they mapped characteristics of smart city participation and added in three new columns; the first column relates to the role expected by citizens; the second additional column refers to the

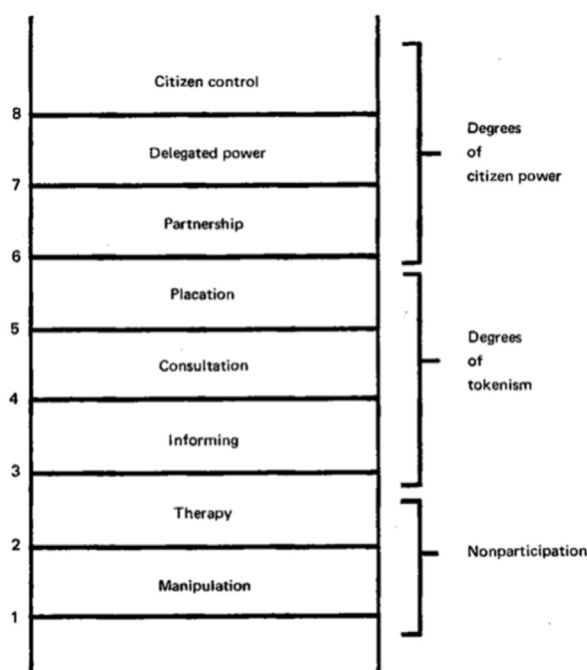


Fig. 1. Arnstein's ladder of participation (adapted from (Arnstein, 1969)).

political discourse; the final additional column is the modality as to how citizens are positioned within the smart city (refer to Table 2. Scaffold of Smart Citizen Participation (Cardullo & Kitchin, 2018). In relation to emotional data, Cardullo and Kitchin raise important concerns around the role citizens in market-driven smart city initiatives where data is monetised by companies for commercial purposes such as location-based marketing (2018). This highlights that there are few examples where ‘citizen control’ has been implemented in the smart city; and participation often does not empower citizens. Pritchard and Gabrys identify a significant gap between collecting data and “*coming together as a community with the common resources needed to make that data actionable, or even to initially define the problem*” (Pritchard & Gabrys, 2016). They argue that whilst it is assumed that participatory sensing will enable democratic modes of engagement, community participation and involvement, this is often not the case.

2.3. Emotion data and planning

Whilst data is seen as integral to smart city approaches, the link between emotional responses and the built environment and urban planning decision making is underexplored (Raslan et al., 2014). Emotion is not seen as a valid metric that can be included in decision making since planners tend to believe that subjective emotions should not influence their analysis or recommendations (Baum, 2015).

Table 1
Emotional Data projects mapped against Arnstein's categories of participation.

Project Name (authors)	Nr of participants	Emotional Data Types	Participant Role	Citizen Involvement	Political and governance context	Form of Participation (after Arnstein)
Bio Mapping (Nold, 2009, 2018)	1500+ participants (in multiple locations)	GSR, self-reporting, drawings, focus groups, collective map	Collaborator	Data collection and analysis, Problem definition, Planning recommendations	Art project/ Urban planning	Partnership
Emotion Map of Olumac (Pánek, 2018, 2019, Pánek, 2020)	2117 participants	Paper Maps, Emotion Maps Digital Mapping	Collaboration/ Participant	Data collection, data analysis	Urban Policy	Consultation
The Urban Brain (Aspinall et al., 2013)	12 participants	EEG (Emotiv EPOC)	Research participant	Data collection, data analysis	Research project	Consultation
Wimo (Modý et al., 2009)	8 participants	GSR, self-report, digital map (app)	Research participant	Data collection, data viewing	Research project	Consultation
Engaging the senses (Fathullah & Willis, 2018)	8 participants	GSR, self-report, digital map	Research participant	Data collection,	Research project	Consultation
Urban Emotions/ Humans as sensors (Resch, 2013a; Zeile et al., 2015, 2016)	12 participants (Cycling study (2016))	GSR and EEG, people as sensors app, Gopro video, digital map	Research participant	Data collection	Research project	Consultation
Imprecity (Nenko & Petrova, 2018)	15 participants	self report on app	Research participant	Data collection	Research project/Design students	Consultation
Invisibility (Deitz et al., 2018)	Small group (number not known)	self report on app	Research participant	Data collection	Research project/design students	Consultation
Mindrider (Ducao, 2015)	n/n	EEG data (dedicated helmet device)	Consumers	Data collection	Commercial project	Placation
Sensometer (Shoval et al., 2018)	144 participants	GSR and self-report	Research participant	Data collection	Research project	Informing
EmoMap (Capineri et al., 2018; Huang & Gartner, 2016; Klettner et al., 2013)	Approx. 200 participants	Self-report sentiment data in dedicated app, digital map	Research participant	Data collection	Research project	Informing
I know how you feel (Schneider et al., 2020)	n/n	Movisens app on Pedelec bike	Research participant	Data collection	Research project	Informing
Mappiness (Mackerron & Mourato, 2013; Seresinhe et al., 2019)	15,444 users	Self-report sentiment data in dedicated app, digital map	App users	Data collection	Research project/ commercial project	Manipulation
Pulse of the Nation (Mislove et al., 2010)	n/n (300 million tweets)	Twitter data, digital map	Social media users	Data collection, data viewing	Research project/ commercial project	Manipulation

Table 2
Bethlehem Biopsy mapped against Arnstein's categories of participation.

Project Name	Data Type	Participant role	Citizen Involvement	Political discourse/framing	Forms of Participation (after Arnstein)
Bethlehem Biopsy (2009)	GSR, self-reporting, focus groups, sketch drawings, collective map	Collaborator	Data collection and analysis, Problem definition, Planning recommendations	Art project with action research methods/Urban planning process with Mayor involved	Citizen Power: Partnership

As a result, planners typically lack the tools to include citizens' emotional interactions with urban environments in city consultation and planning processes. However, developments in the last decade of readily available biostatistical and sensor technology using GSR and EEG measurements, as well as sentiment analysis of social media have made the gathering of emotional data much more widely accessible.

3. Method

To understand how emotional or biometric data could inform participation in the urban planning process we undertook a two-stage method. Firstly, we made a thorough literature review and analysis of projects that have used the method and from this we develop a framework that maps the participation against Arnstein's ladder. We then present the results from a case study (Yin, 1994) where we look at one project in further detail and then apply the framework.

3.1. Literature review of emotion data projects

We undertook a review of literature of empirical studies that have used emotional data to address urban or spatial planning challenge. We then sought to categorise projects against characteristics from Arnstein's participation criteria to understand three aspects; 1) the role of emotional data 2) the nature of citizen participation and 3) how it contributes to the smart governance process.

3.2. Case study

We tested our framework against a case study project. We describe the project and then analyse its outcomes against the framework to understand how it addresses participation in urban governance. The Bethlehem Biopsy case study is part of the 'Bio Mapping' project, which started in 2004, and was the first to integrate biometric emotion data and GPS location into cartographically visualisations (Nold, 2009). In the fieldwork, Nold measures the change of the skin conductance levels of participants wearing a GSR device as they walk around a city, which is mapped to locate features of the environment that trigger emotional arousal. Afterwards, participants sit together in small groups to analyse the data and use it to articulate individual and collective responses and their relation to local issues in the local area. The final designer emotional map that is created from the study shows that an emotional response that includes noticeable reactions to notable urban features and social interactions (Nold, 2009).

While the Bethlehem case study is now more than ten years old, it is still the largest in terms of number of participants and the most refined example of the use of GSR sensing that offers citizens a direct relationship to urban planning. It has not previously been analysed as an example of urban planning, and a key contribution of this paper is to highlight the importance of this project as an exemplar for future urban planning projects.

4. Results

4.1. Literature review of emotion data projects

The literature review identified twenty papers with empirical work undertaken between 2008 and 2019 that documented the ways in which emotional data from GSR and EEG devices as well as sentiment data from social media could be used to inform an understanding of the link between people and urban environments. We limited our review to projects that used GSR, EEG or sentiment data in the context of some form of urban analysis or mapping, and excluded desk-based studies; those that used analogue methods (e.g. 'psychogeography' projects) and those that lacked a spatial component (e.g. (Chrisinger & King, 2018; Doran et al., 2013; Hauthal & Burghardt, 2013; Jang & Suh, 2010; Klettner et al., 2013; Pykett et al., 2020)). The literature review covered a range of small research projects with limited number of participants in controlled environments, city wide participation linked to urban planning projects and through to online only projects that crowdsource sentiment data from social media feeds (see Table 1). The table presents the results, mapped against Arnstein's categories of participation. At the bottom of the table are projects that crowdsource emotional data and can be characterised as 'manipulation', whilst at the top of the table, are projects that demonstrate a 'partnership' that involves citizens in both the GSR data gathering and the urban planning process.

Analysis of the literature review reveals that the majority of projects are small-scale one-off experiments (typically with less than twenty participants), which are led by academic researchers. The papers usually focus on the technology and there is a lesser focus on discussion of the selection criteria or strategy for recruitment of participants or the specific locations used for the experiments. It is

notable that there are few papers that describe the use of emotion data specifically for urban planning or governance purposes, and that where they often do not demonstrate how they contribute to citizen power. Therefore, to understand the role that emotional data can play in meaningful participation in smart urban governance, we discuss in the next section a case study of a 'Bio Mapping' project in the city of Bethlehem, USA that sought to address local urban planning challenges using a participatory framework.

5. Results: case study of 'Bethlehem Biopsy' (Bio Mapping)

5.1. Project context

The project was initiated as an arts residency by Lehigh University who invited Christian Nold to develop a one-month participatory art project in Bethlehem, Pennsylvania USA. The aim was to engage local participants to create an emotion map of the town using the Bio Mapping approach that had previously been used around the world with local communities. Bethlehem is a small town along the Lehigh River with a population of 75,000 residents. It is famous for its now defunct steelworks that was once the second-largest steel producer in the US. Like many US towns, Bethlehem is heavily focused on car transport and with the bridges that connect the two halves of the city heavily prioritising cars. The central part of the town is a food desert requiring car transport to out of town superstores for affordable food.

The project involved 250 local residents and members of the town council in workshops that consisted to emotion data collecting walks and created drawings that were used to create a map that captured the collective emotional dynamics of the town. The project received significant radio and print coverage with journalists attending the public events. While the project had not been initiated as an official urban planning process, it unexpectedly took on this role as participants and institutional stakeholders saw the value of the project and endorsed it publicly (Fig. 2). The newly elected city mayor was keen to improve pedestrian options in Bethlehem and lent his support to the project as a form of urban planning for Bethlehem. In addition, several stakeholder groups used the project to develop plans for cycling provision and better food provision for low-income residents.

5.2. Citizen involvement

The project was publicised on public radio, newspapers and TV as well as via posters in cafes and the university. Participation was open and there was no demographic targeting. The events were organised inside cafes and art galleries to create a relaxed atmosphere for the multiple activities the participants could take part in. Participants could create drawings in relation to a variety of prompts such as 'draw a typical Bethlehem person'. The main activity involved participants being wired up with the Bio Mapping device invented by Christian Nold in 2004 which consists of a GSR sensor and a GPS unit. Participants went for a walk in the local area for an hour and on their return the physiological data and walking were graphically displayed as a 3D track of peak and troughs in Google Earth. The participants took turns interpreting their physiological data and describing their sensations on the walk and added textual observations on their route. This activity took place in a group setting and people often commented on other walks to identify common features that triggered emotional arousal and talked about changes they wanted to see in the area. The textual annotations involve responses to



Fig. 2. Participants including the Bethlehem mayor taking part in the workshop wired up with the Bio Mapping devices.

physical features such as “Looking at the blast furnaces I was thinking how I fought for them” as well as social encounters such as: “Little boy playing soccer who said hello to me”. Some of the comments are personal responses such as: “My girlfriend who lived here passed away one month ago and I cried. I was so sad”, while others are responses to common urban features such as: “Make this a one way road!” and: “I am on the south side of the river and I would like to go to the north but there is no way for me to get up onto the bridge. I am trapped”. The resulting map was designed by Nold to combine the collective quantitative GSR data and the qualitative data of people's recollections from their walks as well as the drawings (Fig. 3).

5.3. Data types

This was a mixed methods project and the emotion data in this project consisted of multiple kinds: the physiological data recorded by the Bio Mapping device, the textual annotations of people's walks as well as drawings made of significant aspects of the town (Fig. 4). Gathering the physiological data was an important motivation for people to participate since they were curious about their reactions to the local area. The collective public emotion data promised to provide an overview of public opinion that was attractive to the mayor and economic development team. There was an emphasis on making the process of the project transparent and accessible via public workshops and presentations where people's data, responses and drawings were directly entered onto the collective map and visible to others taking part. The project involved the mayor and other stakeholder groups in working with unfamiliar data in the mix of quantitative GSR data and qualitative descriptions and drawings. Nevertheless, the fact that they participated themselves and that the data was computerised and allowed the 250 citizen responses to be aggregated meant the project was “‘readable’ within existing technical and institutional epistemic systems of governance” (Nold & Sobecka, 2021). As a result, the data from the project was ‘surprisingly’ useful for public planning despite using unfamiliar emotion data.

5.4. Citizen data and its role in the planning process

The public planning aspect of the project emerged gradually as individuals and institutional stakeholders started to see the value of the project. Often the planning aspects emerged from personal discussions about their experiences on a walk around the abandoned steelworks. The group dynamics often lead to individual experiences becoming broader discussions about collective ideas, visions, and frustrations that people wanted to share. The fact that participants were walking with the Bio Mapping device, meant that many of the planning topics revolved around issues from a pedestrian perspective. This created surprising connections between topics such as pedestrian safety came to be linked with urban food deserts created by a lack of car transport and poor cycling provision.

The project became a gathering space for an informal coalition between multiple local cycling and food access initiatives that helped to articulate a series of planning suggestions that targeted geographically localised issues. As a result, seven emergent discussion areas were identified, for which the project team offered a specific planning recommendation for each one.

For example, Sand Island was identified as an area of untapped recreation potential where participants proposed the idea of an eco-

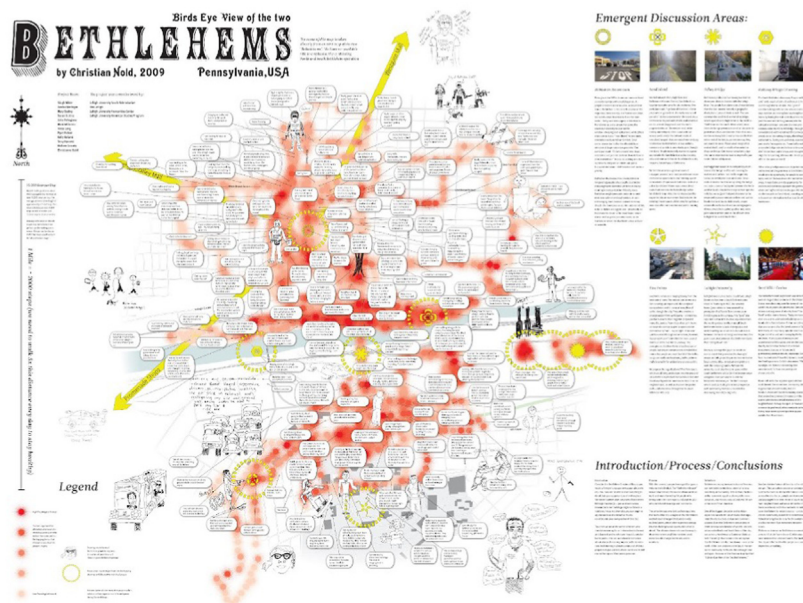


Fig. 3. ‘Birds Eye view of the two Bethlehems’ map (Coombe, 2009). The red is the physiological arousal data with intense areas indicating high arousal. The texts are participant's commenting on their arousal data and experiences on the walks. The drawings were geolocated or clustered into issue groupings. The emergent discussion area is on the right. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

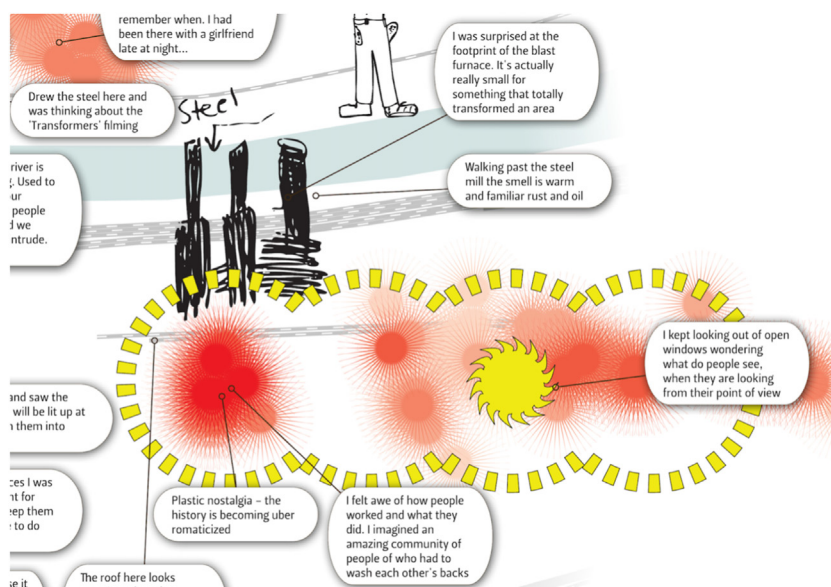


Fig. 4. Detail of the 'Birds Eye view of the two Bethlehems' map (Coombe, 2009).

centre with bicycle facilities. Another example was the central bridge that connects the two halves of the town, was identified for its poor pedestrian access from the river. The participation of the mayor and town's economic development team as well as their public endorsement of the project added legitimacy to these planning recommendations from the project.

This shows that the role of urban planning in such projects is not to define agendas in a top-down way via an emotion layer but to respond to and follow-up the unexpected connections identified by citizens in articulation of urban sensations. Emotion data is thus different from other forms of urban data that are routinely used as part of urban planning, in that it is not just an epistemic object, but also a performative process that stimulates new associations between citizens and planners. This approach to emotion data also supported by other studies (Pánek, 2019) that empathise the role of these projects in creating connections between citizens and local government.

5.5. Ladder positioning

The distinctive aspect of the Bethlehem case study was that the public were involved not just in generating emotion data but also in analysing it and using it for problem formation and definition. A key reason for this was that the project was initiated as an independent, open-ended art project without institutionally defined planning objectives. This openness allowed emotional responses of individual residents to be shared with others and used for collective problem formation and translated into planning recommendations. In addition, this structure also allowed formal stakeholders such as the mayor, economic development team and local interest groups to use the project to articulate their problem definitions. The citizen participation in the Bethlehem Biopsy project is a form of partnership in Arnstein's ladder due to the way the public and city's policy makers were directly involved in all stages of data collection, analysis and problem definition (see Table 2).

The project does not represent full citizen control since it relies on external elements that need to be brought in for the duration of the project (external artist and specialist hardware). This means the project can only function as a temporary intervention rather than a continuous process of planning.

6. Discussion: emotional data and smart city governance

6.1. What does emotion data do? beyond the 'humans as sensors' approach

In this paper, we have reviewed how the 'humans as sensors' approach frames people as sensors where the aim is to gather and transform people's subjective feelings into quantifiable emotion data. Resch and others argue that 'humans as sensors' can replace high input qualitative data gathering such as interviews, focus groups and surveys which are "complicated, error-prone, and unreliable" (Resch, Sudmanns, et al., 2015). But this fails to address important questions such as who should, can, or does serve as a human sensor and how we determine if they are the 'best', 'right' or most 'useful' collectors (Littlefield, 2021)? p.195). This vision aims towards a kind of cybernetic governance where the public function as 'sensors' that makes public-planning an objective and rational process, where sensing emotion and perceptions become a way of replacing politics and disagreement and citizens becoming 'data products'. This reflects some of the challenges identified within the urban science field which is produced through "overly-simplified explanations and models, and a limited and limiting understanding of how cities work (foreclosing what kinds of questions can be asked and how they can be

Table 3
Emotional data framework.

Participation category (after Arnstein)	What does the emotion data do?	What is the participant role?	What is citizen activity?	What role does citizen data play in politics and governance?
Citizen Power	Emotion data is part of a mixed methods approach including subjective validation of qualitative data <i>Is the data contextualised with self-reporting and mixed methods insights?</i>	Initiator and/or collaborator <i>Can participants choose different levels of involvement?</i>	Problem definition, volunteered data collection <i>Can the participants define the problem?</i>	Direct involvement in urban governance process <i>Are diverse participants included?</i>
Tokenism	Emotion data is used as a representation of public opinion. <i>Is the data gathered accessible to participants?</i>	Participant <i>Are participants passive?</i>	Qualify and sometimes interpret the data <i>Do the participants only qualify and interpret the data?</i>	Limited involvement in the governance process. <i>Do participants understand the urban governance problem being addressed?</i>
Nonparticipation	People used as sensors without understanding. <i>Is the data gathered without participant involvement?</i>	Data Subject <i>Do the participants know how their data is being used?</i>	No involvement with outcomes <i>Do the participants have knowledge of the project?</i>	No involvement or relevance in the governance process. <i>Are participants involved in the governance process?</i>

answered) and how urban issues can be tackled” (Kitchin, 2019). Therefore, it is important to recognise that emotional data is contextual and requires extensive interpretation and collective negotiation to be useful for urban decision making. In the Bethlehem case study, the participatory emotional data moves beyond the role of participant as passive ‘data product’ to being actively involved in making sense of the data and using this as a method for problem definition and agenda setting in urban planning.

6.2. Emotion Data Framework for participation in smart city governance

We developed the ‘Emotional Data Framework’ as our original contribution from this paper that enables the identification of whether a project contributes to citizen power in Arnstein’s terms (Table 3). The framework is developed from the results of our study; the literature review of emotional data projects (Table 2) and the Bethlehem Case study. We propose that this framework can be used as a guide for researchers and urban planners to assess whether the design of a project using emotional data contributes to citizen power in terms of Arnstein’s original ladder of participation.

The Emotional Data Framework aligns four aspects of emotion data use in urban governance; then role of data, the role of participants, the activity and the contribution to urban governance, against three core criteria from Arnstein; citizen power, tokenism and non-participation. In order for the framework to be used in a reflective manner we have also included a sensitising question for each category to help make the determination. For instance, in order for a project to enable citizen power, we propose the following question is positively addressed: “*Is the data contextualised with self-reporting and mixed methods insights?*”, and that the activity involved proactively responds to the question “*can the participants define the problem?*”. The Emotional Data Framework also includes Arnstein’s categories of tokenism and non-participation, so that it is possible to also identify and highlight the aspects of a project that do not enable citizen power which we propose can distinguish between project rhetoric and the reality of modes of participation.

The Emotion Data Framework identifies the key criteria that a project should aim to achieve using emotional data is identified as follows: multi-dimensional emotion data, active participant role, extended participation within the planning process, empowerment within urban governance. The importance of a mixed methods approach with GSR data is highlighted by Osborne and Jones (2017) who conclude that biosensing offers a powerful tool for understanding individuals’ responses to physical environments, but only when used in combination with other datasets (Osborne & Jones, 2017). The Emotion Data Framework therefore demonstrates that emotion data needs to be used as part of an ecology of participatory processes and suggests they can be combined with other existing low-tech paper planning processes.

7. Conclusion

The current smart city technocratic approach typically uses physiological sensors and crowdsourced data to build an emotion layer for governance and planning. In fact, the ‘storytelling’ modality of smart urbanism is usually contrasted with the everyday reality of citizens trying to coexist in the city with these technologies, where they merely gather data and act as sensors for free rather than becoming participating in any active decision-making. Our literature review of emotional data projects that have sought to inform urban planning decision-making found that few projects have meaningfully moved beyond tokenism or placation in the way they engage participants in the process. There are few cases of ‘citizen power’ in terms of urban planning and this highlights that participation is often instrumental rather than empowering in a political sense.

In this paper we have demonstrated the need for an alternative approach that sees emotion data as a dynamic leverage point of negotiation in smart city governance between citizens, the urban space and civic agencies. We argued that emotional data can distinguish itself from other modes of participatory data when it used to bridge the knowledge gap between urban data from sensors and subjective data from the individual, which we identified above is often missing from the rational model of urban planning. Therefore we developed an Emotion Data Framework that aims to address this gap in knowledge. If emotion data is used to enable citizen power, the

framework demonstrates that it needs to consider four aspects; the multi-dimensional emotion data; an active participant role; extended participation within the planning process, and empowerment within urban governance. If used in this way the framework can be a method for creating empathy and understanding for public participants and urban planners alike that can cut through institutional boundaries. Emotion then becomes a method for collaboration since it enables participants to articulate their feelings about particular spaces with the result that emotion itself becomes an articulate force for connecting entities around issues of concern. As the Bethlehem case study shows, the connection between cycling and food access was made only because the project allowed citizens to see and articulate their shared emotions about walking the city, and this created a leverage point for meaningful processes of debate and decision making between citizens and urban policy making. Emotional data can then become a means of creating unexpected connections between people and issues that would otherwise not be part of smart city governance.

Author contributions

KW and CN developed the topic, methods and analytical framework, analysed the data and wrote the paper; CN designed and conducted the case study field work.

Declaration of competing interest

The authors declare no conflicts of interest.

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