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Emotive facets of place meet urban analytics

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The lack of a well-established and unified place theory across disciplines is decelerating its formalization, evolution, and especially its pragmatic implications and applicability. In this article, we identify research gaps in the emotive facets of place scholarship. We found that it (i) rarely joins physical, social, and individual variables in the same model, (ii) omits the immediately perceived and sensory dimensions, (iii) disregards the analysis of how individual-place emotive relationships vary across time, and (iv) overlooks the difficulties of reducing multifaceted emotive facets of place into geographic features. Next, we examine these research gaps through the lens of technology-based advancements in urban analytics. Finally, we discuss the need to combine social-oriented research and (spatial) data-driven disciplines to enrich and expand the research area of emotive facets of place and connected disciplines.

KEYWORDS

emotive facets of place, GIScience, urban analytics, data-driven studies, place-based research

1 | INTRODUCTION

Places are shaped by the unique experiences, perceptions and cognition of a person or community, and cannot be simplified into a mere spatial relationship without losing their human connotation (Norberg-Schulz, 1980). This is what makes each place unique in the universe (Gieryn, 2000). In turn, the complexity and multi-faceted nature of a

place make it difficult to quantify and require a multidisciplinary research approach (Merschdorf and Blaschke, 2018). Although some areas of knowledge such as GIScience and human geography have grounded theories, anthologies, and models to articulate the complexities of place – see for example, (Scheider and Janowicz, 2014a; Purves *et al.*, 2019; Agnew, 2011) – the implications of how to mobilize the pragmatic side of place-based knowledge still has a long road ahead (Tang and Painho, 2021). This issue can be partly explained by the poor guidelines, protocols and tools to embed sixty years of place theory in social research into data-driven studies and GIScience.

Social science disciplines such as human geography, sociology, and environmental psychology have been deeply connected to place and place-based theories for decades and the concept still raises great interest, e.g., (Raymond *et al.*, 2017; Newell and Canessa, 2018; Lewicka *et al.*, 2019). Concepts such as sense of place, place attachment and place identity have been framed, measured and analyzed to study their implications in tourism-related businesses (Liu and Cheung, 2016; Gross and Brown, 2008), natural environment (Bonaiuto *et al.*, 2016; Brown and Raymond, 2007), and civic engagement (Lewicka, 2005; Acedo *et al.*, 2019) – just to provide some examples. As each place in the world is shaped by cultural and social values, studies analyzing place-based concepts also inherit these geographical specifications and complexities. Consequently, although the definitions of those concepts are well-established in social science, their pragmatic study is clearly dependent on contextual and social factors emerging from each case study. This is yielding a pool of questions, models and methods to study place-based concepts, which enriches the literature but also complicates unified data collection and conceptualizations, essential for modelling them computationally (Hamzei *et al.*, 2020a).

Within (geographic) information science, scholars focused on place-based research are mainly investigating exploratory, prototypical methods of analysis (Papadakis *et al.*, 2019; Westerholt *et al.*, 2018b; Jenkins *et al.*, 2016), methods to visualize places (Westerholt *et al.*, 2018c), theoretical differences between place and space (Goodchild and Li, 2011), and development of place-based ontologies (Ballatore, 2016; Scheider and Janowicz, 2014b; Purves *et al.*, 2019). The mentioned works are only a sample of the recent broad attention for the notion of "place" in GI-Science. However, as Goodchild and Li (2011) already noted, there is still an outstanding opportunity for the integration of social science in geographic information technologies. Unfortunately, the exchange between GIScience and the humanities usually has been limited to introducing Geographic Information Systems (GIS) standard capabilities into humanities projects (Bodenhamer *et al.*, 2013). GIScience methods can be enriched and best offered with a deep connection to the social science literature, rather than simple deriving knowledge and conceptualizations from human geography (Purves *et al.*, 2008).

Fields of study that focus on sensing and collecting data in urban environments also provide useful insights to socially-oriented disciplines and place-based studies. For example, urban analytics research quantitatively examines urban environments analyzing huge amount of data from individuals, environment, and the urban fabric. In this study, we highlight the potential contributions of current methodological trends and technology in urban analytics research to detect and analyze individuals' emotions and thus better articulate the emotive facets of place. Guided by a recent systematic literature review on place facets (Hamzei *et al.*, 2020b) and key blind spots detected in sense of place scholarship (Raymond *et al.*, 2017), we distil a set of research gaps in the study of the emotive facets of place and suggest how current urban technology-based methods in urban analytics may help to address them. We then elaborate on the contributions, a set of disciplines that can benefit from this research. Finally, we present an illustrative case study, followed by a conclusion.

2 | EMOTIVE FACETS OF PLACE: DEFINITION

In GIScience, researchers have focused on mathematically defining place reference systems (Scheider and Janowicz, 2014a), its composition (Papadakis et al., 2020), and conflating place-related disciplines to revisit the role of place (Merschdorf and Blaschke, 2018). From a human geography perspective, Agnew (2011) conceived the so-called three dimensions of place: location, locale and sense of place, while phenomenological scholars are more interested in what makes the essence of immediate place experience (Tuan, 1974). More recently, a systematic literature review conducted by Hamzei et al. (2020b) is one of the few multidisciplinary studies covering the various aspects or facets in which a place can be perceived. In this literature review, 116 place facets from different areas of knowledge were identified, which allows a useful cross-sectional examination of the notion of place. A facet is defined as "a particular type of information about (geographic) place that has been defined, described, or formalized in the literature and at the same time can be used to differentiate places from each other" (Hamzei et al., 2020b, p. 2). The mentioned study used card sorting (Spencer, 2009) and hierarchical clustering (Johnson, 1967) techniques to extract and classify the facets encountered in the literature into three main categories: linguistic, derived, and primitive. The latter is further split into geographic and anthropocentric facets. In this study, we focus on the anthropocentric place facet to investigate how the characteristics of place are shaped by the experiences, perceptions and cognition from individuals. For this reason, we focus on the emotive facets within the anthropocentric ones, considering them as a compound reflection of the feelings, attitudes, experiences, and behaviors that people associate with specific geographical areas.

Hamzei *et al.* (2020b) describe 20 emotive place facets defined by 24 studies. Table 1 shows the name of these 20 emotive facets and the related references used by Hamzei *et al.* (2020b) to define and differentiate them. The 20 emotive facets of place are interrelated and mainly characterized by conceptualizations with no formalism (Hamzei *et al.*, 2020b). This may lead to overlapping meanings that might prompt similar definitions for different conceptualizations. Then, some of the concepts within the table are repeated because different authors described different conceptualizations. For example, the concept of place dependence is defined as *"How far the place satisfies the individual's behavioral goals as compared to other alternative"*(*Obaid S. Almuzaini, 2017, p. 50*) and *"I consider place dependence to be more-or-less similar* (to place identity), although strictly speaking it might be seen as the self-perceived strength of association between an individual and a specific place"(*Vanclay, 2008, p. 8*). Both conceptualizations are included in the study, the former as place dependence (1) and the latter as place dependence (2). This ambiguity is present in other concepts of the Table 1 – for all the related concepts' definitions see Hamzei *et al.* (2020b).

3 | EMOTIVE FACETS OF PLACE: RESEARCH GAPS AND LIMITATIONS

We revised and hereby extend the study of the emotive facets of place uncovered in Hamzei *et al.* (2020b)'s systematic literature review. Based on this review, we readdress the critical blind spots in the sense of place scholarship unveiled by Raymond *et al.* (2017). Where Raymond *et al.* (2017) examined these gaps from the viewpoint of affordance theory, we reinterpret and extend these gaps through the lens of urban analytics. Next, in Section 4, we analyze how current technology-based methods in urban analytics may help in addressing the key research gaps in the emotive facets of place research.

3

Emotive facet of place	References
Sense of place (1)	(Tuan, 1978; Massey, 1994; Capineri, 2016; Canter, 1997; Cresswell, 2004; Entrikin, 1991; Harrison and Dour- ish, 1996; Purves and Derungs, 2015; Edwardes, 2007; Purves <i>et al.</i> , 2008; Buttimer, 1976)
Salience	(Winter and Freksa, 2012; Richter <i>et al.</i> , 2013; Winter and Truelove, 2013; Obaid S. Almuzaini, 2017)
Place attachment (1)	(Scannell and Gifford, 2010; Tuan, 1978)
Specificity	(Scannell and Gifford, 2010)
Social elements	
Salience of place (absolute view)	(Obaid S. Almuzaini, 2017)
Salience of place (personal view)	
Place Dependence (1)	
Place social bonding	
Place affect	(Obaid S. Almuzaini, 2017; Cresswell, 2004)
Sentiment (individual reflection)	(ElGindy and Abdelmoty, 2014a,b)
Emotional Attachments	(Mennis and Mason, 2016)
Spatial Value	(Quesnot and Roche, 2015)
Spirit of place	(Vanclay, 2008)
Sense of place (2)	
Place attachment (2)	
Place dependence (2)	
Place familiarity	
Place identity (2)	
Place commitment	

TABLE 1 The emotive facets of place extracted from Hamzei et al. (2020b)

3.1 | The emotive facets of place research rarely join physical, social and individual variables

The joint study of physical, social and individual constructs, in the same model, to explain place meanings is not a common practice in the emotive facets of place literature. Although current technological advancements provide resources to obtain valuable information from different aspects of the urban context, it is uncommon to find place-based studies that use them in combination to analyze the emotive facets of place. In general, researchers use social network analysis, crowd-sourcing methods, and volunteered geographic information technology to collect information about individual-place relationship from the urban context (Hu *et al.*, 2019; Jenkins *et al.*, 2016; Resch *et al.*, 2016; Capineri, 2016; Zhang *et al.*, 2018). Specifically, researchers use geotagged image libraries and digitized archives of historical text documents (Purves and Derungs, 2015), human ratings of street-level imagery (Zhang *et al.*, 2018), place descriptions (Richter *et al.*, 2017; Saeidi *et al.*, 2016; Chapman *et al.*, 2018), travel blog entries (Adams and McKenzie, 2013), and online neighborhood reviews (Hu *et al.*, 2019) as proxies to understand and predict sentiments, emotions, and perceptions attached to specific neighborhoods or places.

All these mentioned studies show several sources of information to partly collect the variables that shape the multifaceted nature of the emotive facets of place. As multilevel relationships are likely between elements of the mind, environment, and cultural systems, it is not possible to read aspects of behavior neglecting the features of the intertwined socio-cultural system (Raymond *et al.*, 2017). Places and their meanings can be influenced by socio-cultural processes or architectural, material or economic elements. All of this results in a complex and dynamic scenario that requires information from individuals, the geographical context, and the surrounding socio-cultural environment. Yet, there is a lack of an established quantitative and formal methodological toolbox to explore place-based conceptualizations and components that account for the varied present and mentioned factors in the urban context.

3.2 | The emotive facets of place research omits the immediately perceived and sensory dimensions

The contributions of the physical environment and contextual effects in the individual-place relationship has been absent in most psychological discussions (Stedman, 2003). Although literature provides many studies on questions and models to collect and analyze the emotive facets of place, the contextual circumstances and local factors at the moment of the perception are underestimated in the analysis (Vanclay, 2008). Few studies are collecting the emotive facets of place in situ, or detect and mix useful information when individuals are answering about or feeling the emotion produced by a place. The main source of information about emotive facets is extracted from intellectual abstraction, representation, or computation shaped by participants' experiences using questionnaires, structured and semi-structured interviews (Brehm *et al.*, 2012; Carrus *et al.*, 2005; Brehm *et al.*, 2006; Raymond *et al.*, 2010; Zia *et al.*, 2014; Ojala and Lidskog, 2017; Mesch and Manor, 1998). Moreover, these methods usually ask individuals to recall events or situations long after the event occurred, minimum one hour later (Pitta *et al.*, 2006). Due to this fact, the role of in situ perceptions when developing the emotive facets of place is unclear. Additional effort needs to be made in providing tools and resources to include direct perceptions, sensory dimensions, and contextual effects into existing models and analyzes for emotive facets of place.

3.3 | The emotive facets of place research disregards the analysis of how individual-place emotive relationships vary across time

The study of time in relation to the emotive facets of place has been mainly focused on the comparison between natives and non-natives' developed attachment to a place, and the variable time as a mediator of the development of individuals' place attachment. For example, sense of place permits new residents to foster adaptation, exploration, and engagement in new environments (Fan, 1998), and it develops differently based on age, social and cultural capital, family situation as well as socioeconomic characteristics (Trąbka, 2019). Although the variable time in the form of length of residence is one of the most important in the development of emotions towards places (Raymond *et al.*, 2017; Trąbka, 2019; Lewicka, 2011), attention must be given to how the urban and global change shapes individuals attachments towards places. The unprecedented environmental and urban change is fragmenting the landscape and altering the individual-place relation forged over time (Raymond *et al.*, 2021). Recently, the current pandemic situation has also been a fundamental shift in our relationships with place (Devine-Wright *et al.*, 2020). All these rapidly and profound changes we are experiencing entail a reconsideration and reevaluation of time regarding both emotive facets of place and places themselves.

However, the study of the emotive facets of place disregards the evolution of places and related emotions over time and life stages. One place can be the idyllic park in which a person spent their childhood, but it can become the sad place where his/her dog was run over. The same place with the same appearance acts eventually as a catalyst for positive and negative feelings. Moreover, places can change their morphology or function over time which can also affect people's well-being in different life stages (Moore *et al.*, 2018). That is, a complex time-dependent combination of different variables that define how the individual-place relationship evolve over time and individuals' life course (Raymond *et al.*, 2017). For example, early experiences in a place can determine how a person moves and interacts within this place, transferring old perspectives and connotations to current actions (Newell and Canessa, 2018). However, the difficulty of maintaining longitudinal studies about the same sample over long periods of time is a disadvantage in understanding how our emotions and attachments to specific places evolve over time and people's life stages (Cuba and Hummon, 1993).

3.4 | The emotive facets of place research overlooks the difficulties of reducing multifaceted emotive facets of place into geographic features

It is crucial to determine the level of spatial specificity in which the emotion to an area is developed (Scannell and Gifford, 2010). Brown and colleagues have developed map-based methodologies for measuring individuals' landscape values (Brown and Raymond, 2007; Brown *et al.*, 2015; Raymond and Brown, 2007; Raymond *et al.*, 2010; Brown, 2005; Brown and Weber, 2011) – for more examples see Bubalo *et al.* (2019). Web mapping-based applications have also been developed to gather the spatial dimension of sense of place (Acedo *et al.*, 2017a), to define the spatial imprint of places (Huck *et al.*, 2014), to mark positive and negative emotional experiences along cyclists' routes (Snizek *et al.*, 2013), to evaluate the images of cities (Barros *et al.*, 2021), and to draw on a more comprehensive understanding of local knowledge through location-based questionnaires (Rantanen and Kahila, 2009). These approaches add a spatial dimension to the emotive facets of place: locating the answers and individuals' meanings into maps (e.g., maptionnaire¹) or providing GIS tools to spatially define participants' place-based conceptualizations (e.g., placeandcity²).

Nevertheless, despite the available improved drawing tools, a mapping activity through a web environment is af-

¹https://maptionnaire.com accessed on 23 July

²https://www.placeandcity.com accessed on 23 July

fected by the participants' specific skills, and may prevent the general public from using it broadly (Poplin, 2015). Moreover, web mapping-based surveys have been criticized because the simplicity of the methodology used in attempting to capture dynamic place emotive facets through basic geometries (Acedo *et al.*, 2018). The reduction of multiple, complex emotive facets of place into basic geographical features (e.g., discrete points and/or polygons) comes with analytical and data quality challenges that need to be thoroughly taken into consideration (Brown and Pullar, 2012). In participatory map-based investigations, or any reduction of social constructs to spatial conceptualizations as it is in the case of the emotive facets of place, researchers need to pay special attention to the dynamic, time-dependent nature of the mapped social concepts, and critically discuss the results obtained along their limitations.

4 | EMOTIVE FACETS OF PLACE: TAKING INSPIRATION FROM URBAN AN-ALYTICS

The irruption of recent advances in ubiquitous and mobile technology and analytical tools has contributed to new ways of studying social urban challenges through the massive collection of data from urban environments, individual characteristics and behaviors, and the interaction between them – see (Martí *et al.*, 2019; Shi *et al.*, 2021). However, when it comes to emotive facets of place, the application of these new methods and resources have been less studied. A deeper interplay between traditional research methods used in the emotive facets of place and emerging tools and technologies developed in the context of urban analytics can offer new possibilities and opportunities. Given the rise of new forms of data generated by the computing penetration in the urban fabric (e.g., smartphones, Internet of Things devices, AI-enabled cameras, interactive displays, etc.), interdisciplinary methodologies could provide new avenues to advance in the formalization and operationalization of place-based concepts in (spatial) data-driven studies. The current challenge is to bring existing data, methods, and tools in urban analytics – which has been widely demonstrated in (spatial) data-driven projects – to place-based studies to provide better contextualization and analysis of the emotive facets of place. In the following subsections, we look at recent studies on urban spatial analytics to uncover potential technology-based facilitators to address the research gaps identified in Section 3.

4.1 | Acquisition of multi-source urban data to study the emotive facets of place

In urban analytics, the (smart) city, as the central object of study, can be characterised by its sensed data. New sensing Big Data streams such as smart building and community readings in terms of energy use, resilience, sustainability and risks (Jia *et al.*, 2019; Chang *et al.*, 2020), and environmental sensing in terms of air quality, ambient light, presence of allergens (Chen *et al.*, 2018), are gaining relevance when used in conjunction with open public data sets to improve, for example, urban policy and planning (Thakuriah *et al.*, 2017; Kandt and Batty, 2021). The anthropocentric side of the city is usually collected from people's interaction with social media (e.g., Twitter), governments (e.g., census, participatory processes), urban infrastructures and services (e.g., urban traffic, public transport). The proper integration of all mentioned sources can convey places' socio-cultural and historical meaning to help in the contextualization of individual-place relationships. However, the inclusion and quantitative combination of multiple, heterogeneous data sources, as well as different granularity, semantics, time, and spatial scales to study the emotive facets of place is a challenging process. Yet, relatively less sophisticated solutions can partly alleviate the complexity of the method if the loss of versatility, scalability, and dynamism of updating the collected data is to a certain extent reasonable in a study case. For example, processing multiple data sources beforehand to form richer but static data sets for a city or area of interest could benefit the study of place-based concepts. Examples of such solutions are already in the market

such as GeoEnrichment³ and in the literature (e.g., SocialGlass) (Psyllidis *et al.*, 2015) that join diverse data sources by location. This multi-source data acquisition and integration pertinent to people, built environment, natural environment, and the connections thereof, definitely enrich current place-based studies with sensor, publicly available municipal records, and resources from knowledge repositories. All these data sources and information can influence individual-place relationships and, thus, help to better understand the emotive facets of place.

4.2 | Real time in situ approaches to study the emotive facets of place

The introduction of the experience-sampling method (ESM) in the 70's has significantly improved the exploration of subjective self-reported emotion in real time (Shoval *et al.*, 2018; Csikszentmihalyi *et al.*, 1977; Nowlis and Cohen, 1968; Côté and Moskowitz, 1998; Pavot *et al.*, 1990; Larson *et al.*, 1994; Oishi *et al.*, 2004; Flory *et al.*, 2000). In brief, ESM refers to "a method of data collection in which participants respond to repeated assessments at moments over *the course of time while functioning within their natural settings.*" (Scollon *et al.*, 2003, p. 5). Recently, the possibility to gather place-based information "on the move" using mobile platforms provides alternatives methods to collect local connections to a place (Evans and Jones, 2011), and a valuable method for geographers to better understand the constitutive relationship between self and place (Finlay and Bowman, 2017). The increased use of smartphones in the last decade has supported the application of ESM techniques for studying the emotional dimension of urban contexts using smartphone apps (Birenboim, 2016; MacKerron and Mourato, 2013; Birenboim *et al.*, 2015; Mennis and Mason, 2016; Solymosi *et al.*, 2015; Shoval *et al.*, 2018). More recently, the appearance of wearables and ambulatory sensing has allowed the measurement of emotional arousal or other physiological markers. By using this last approach, researchers have deeply investigated emotional responses in outdoor environments in health care (Birenboim *et al.*, 2019; Kyriakou and Resch, 2019; Pantelopoulos and Bourbakis, 2010; Jovanov *et al.*, 2003), and the eventual addition of emotional responses in the planning of urban settings (Resch *et al.*, 2015a,b).

A multi-method approach to support objective (i.e., sensor measurements) and subjective (i.e., ESM) measures becomes essential to have a better overview of the emotive facets of place in real time. ESM techniques and wearables collect and promote real time interaction, thus the recall bias in reporting experiences and perceptions can be minimized (Scollon *et al.*, 2003). Moreover, the combination of both techniques produces more reliable data: while cultural norms might influence the participants' tone and responses in self-reports of their feelings, perceptions and behaviors (i.e., ESM), wearables and ambulatory sensing evaluate physiological measures which are more difficult to control or intentionally alter. Mixing both approaches to detect emotions, along with other sensor data (such as GPS, accelerometer, gyroscope, microphone) to determine the individuals location, movement and orientation, may provide further insight in the individual's attachment to place (e.g., what activity is the individual performing? what is the individual looking at? what is the surrounding soundscape?). The addition of immediately perceived meanings in place-based studies could discern and contrast the importance of this approach in the intensity or structure of the emotive facets of place.

4.3 | Temporal coupling of the emotional experiences with spatial data

It is as important to systematically collect real time experiences as to incorporate their variation over time in the emotive facets of place research. The addition of time in place-based methods allows to study the evolution of emotions framed in and from places. In urban analytics, longitudinal studies, based on proxy data (e.g., Twitter, smartcard data), of individuals' movements across the city have shown how to deal with mobility models and networks (Barbosa *et al.*,

³https://www.esri.com/en-us/arcgis/products/arcgis-platform/services/geoenrichment accessed on 23 July

2018), space-time prisms (Senaratne *et al.*, 2017), and detect mobility patterns over a prolonged time period (Kandt and Leak, 2019; Kandt and Batty, 2021; Santa *et al.*, 2019). Yet, the use of objective data has taken a rise with the use of GPS sensors in smartphones and wearables; e.g., speed, travel time and delay for intersections and road segments (Strauss and Miranda-Moreno, 2017), traffic and road condition estimation (Bhoraskar *et al.*, 2012), pothole detection (Xue *et al.*, 2016), fall detection in urban context (Lee *et al.*, 2018). The use of both proxy and objective data, combined with location-based technologies, have the potential to provide a precise coupling of the emotional experiences with spatial and temporal data. For example, an individual's emotional state at a certain moment in time can be obtained through analysis of social media data (e.g., tweets, Facebook posts) using automated techniques such as sentiment analysis (Medhat *et al.*, 2014) – for an overview of the different sentiment analysis classification approaches and tools see D'Andrea *et al.* (2015)). Such data may directly be coupled with location (e.g., geo-referenced tweets) or cross-referenced with location-based data (e.g., Uber data, fitness tracking data, geo-game data), which together constitute place-based emotive knowledge over time and paint several spatio-temporal pictures of the individual-place relationships.

The challenges, applied to emotive facets of place, are how to collect the same information over a period of time without loosing crucial individual-place information, and how to analyze and interpret the data in a complex, evolving individual, temporal and spatial environment. Clearly, the acquisition of the evolution of the emotive facets of place from individuals needs extra effort than only getting the binomial information of location and emotions experienced. It requires new mechanisms to consider how the emotive facets of place change according to individuals' place experiences and place meanings across the course of their lives, as well as in the evolving context of urban spaces and the relation of the individual with them. To achieve this goal, the storage, processing and querying of such spatio-temporal data become crucial again. Solutions already implemented in data-driven studies can help to deal with the precise coupling of the emotional experiences with positioning data over time and individuals' life course. For example, (i) SQL (e.g., PostGIS) and NoSQL (e.g., MongoDB) databases, which include spatio-temporal support, (ii) adapted programming models (e.g., MapReduce architecture) that enable batch, offline analysis (Hashem *et al.*, 2016), and (iii) stream processing extensions (e.g., Apache Spark) for real-time processing and reactivity, e.g., Rathore *et al.* (2018).

4.4 | Capturing the dynamic spatial dimension of the emotive facets of place

Research needs to be done on how the emotive facets of place behave differently at small and large spatial scales, providing tools to collate, spatially define and describe distinct places and their nature (Raymond *et al.*, 2017). This is not to clarify the limits of a geographical extension for a group of people in a study case, but to achieve methodologies to aid in the delineation, refinement, and validation of the spatial dimension of the emotive facets of place for a group of participants or community. The dynamism, time-dependency, and scale variability of place-based concepts underline the need for longitudinal time-series studies and a dynamic collection of data for a better comprehension of the emotive facets of place. However, urban analytics and (spatial) data-driven studies had given less attention to how to reflect on the spatial dimension of the emotive facets of place. However, urban analytics and (spatial) data-driven studies had given less attention to how to reflect on the spatial dimension of the emotive facets of place. This lack of interest can be partly explained by the strong discourses in literature about the issue of drawing boundaries to place and place-related concepts (Dewsbury, 2003; Thrift, 2008; Cadman, 2009; Pile, 2010; Massey, 1991) and the complexity of the task itself (Acedo *et al.*, 2018). In any case, geographers and GIScience researchers using methodologies such as public participation GIS (PPGIS) have tried to define the spatial dimension of place-based concepts (Acedo *et al.*, 2017b, 2020; Huck *et al.*, 2014; Brown *et al.*, 2015), highlighting the usefulness of these techniques to define place conceptualizations and how they can reflect on participants' spatial/geographic discounting (Brown *et al.*, 2020).

The conversion of multifaceted emotive facets of place into geographic basic features appears along both spatial

and scalar ambiguity in defining their spatial dimension (Brown and Pullar, 2012). As researchers, we know that place boundaries are compound of vague representations, fuzzy boundaries of dynamic nature (Huck *et al.*, 2014; Jones *et al.*, 2008). These statements seem inevitable to deal with when studying the spatial dimension of the emotive facets of place, but they should not discourage researchers from further investigating it. New methods and methodologies are needed to analytically assess individuals' emotive facets spatial dimension. Smartphones and wearables, as well as data from the urban fabric can directly and indirectly supply real time information of individuals spatial dimension. For example, researchers can estimate the boundary of attachment by combining raw or processed GPS readings (e.g., differential GPS data) from smartphones and the active request to participants to find out whether they are *inside* or *outside* the emotional area. If contextual environmental and urban data are added to the mix, results can shed light on urban variables that might model the emotive facets of place over time and their spatial footprint. Such urban experiments may be of multiple importance in controlling the spatial variability of the emotive facets of place and how they evolve at geographic scales such as a neighbourhood, a city, or a region.

5 | DISCUSSION

Some researchers have argued that "the most obvious access to such [place-based] knowledge is capturing ways in which people externalize knowledge about place" (Purves et al., 2019, p. 1178). We agree with this statement, although we also emphasize the need of concurrently collecting the spatial organisation of our surroundings, cultural context, and immediate sensory perceptions to better understand the individual-place exposure. The interest of GIScience scholars in place-based approaches, see for example, the PLATIAL symposium series (Westerholt *et al.*, 2018a; Westerholt and Mocnik, 2019; Mocnik and Westerholt, 2022), and place-related theoretical research (Mocnik, 2022) has recently been growing. Yet, studies that employ data produced and modelled by subjective, experiential, and relational aspects of place within the field are scarce. The current challenge is then to account for these data and methods for a better conceptualization and analysis of the emotive facets of place and place-based research in the GIScience scholarship. In this study, we provide further evidence on how technology-based advancements in urban analytics research can aid to bridge key research gaps in the study of the emotive facets of place. Such knowledge can facilitate the articulation of the place facets' social-oriented nature into the formalisms of data-driven and GIScience studies.

As it was mentioned throughout the study, little attention has been paid to the potentialities of studying the emotive facets using technology-based advancements from urban analytics. Currently, researchers are gathering and analyzing social data to deal with urban challenges, endorsing and legitimating their (spatial) data-driven approaches from a social-oriented lens. However, social theory and place-based conceptualizations can play a more important role in activating the geographical, human and cultural place-based dimension of data-driven studies and discussions. For example, researchers have investigated psychological and mental states using technology-based methods such as smartphone apps, but technology-wise scholars have not fully embraced social and place-based theory to further develop and enrich their data-oriented methods. The possibilities to scale-up GIScience and data-driven approaches to embed them in the qualitative study and discussion of place-based concepts is barely explored (Westerholt *et al.*, 2018b). Although there is a huge amount of studies analytically explaining the social urban context, there is a need to better translate, combine and connect all this knowledge (i.e., methods, protocols, frameworks) to the place-based conceptualizations and scholarship.

The intent of this research was not to assert that the emotive facets of place research must be subjected to quantitative measures at all costs, nor that the GIScience and data-driven approaches have contributed little to the social realm. We emphasize that researchers who are enthusiasts of quantitatively computing social data must reflect

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on qualitative oriented approaches by suggesting questions and examining hypotheses that reveal the richness in the qualitative research (Stedman and Jorgensen, 2001). The other way round, researchers embracing qualitative studies must encourage the adoption of analytical procedures from technology-oriented quantitative urban studies to standardize and harmonize social data collection processes and models. Both connections would make a huge step forward towards a unified, combined targeted agenda among social and technological disciplines to formalize place-based theory. Being a crucial feature to further embed place-based research and knowledge into several disciplines such as government, urban planning, health, and education. The question now is: are those disciplines ready to absorb this place-based knowledge?

5.1 | Potential disciplines to embed the emotive facets of place

Government and urban planning adoption of the emotive facets of place information would add a useful new social layer into the city. Unfortunately, this type of social information is rarely collected and applied to decision-making and planning processes because of its dynamic, time-dependent, scale variability, and risks subject to privacy concerns. Governments have realised about the importance of ensuring the secure free flow of data, including both types personal and non-personal, in strategic sectors such as environment, industry, health and transportation. For example, Europe's new policy agenda for digital transformation with the establishment of a so-called European data space (Kotsev *et al.*, 2020) would mark a milestone for data transparency, empowerment, and reuse. Governments could benefit from such European data spaces to, for example, gauge the emotive facets of place information from citizens residing in a polluted area, so as to foster timely improvements in health and well-being policies, environment, urban planning interventions and public services. Thus, the operationalization of the emotive facets of place can add new insights in urban planning and decision-making processes by leveraging the complex nature of individual-place relationships. The emotive facets of place are part of person-environment exchanges (Manzo and Perkins, 2006) and as such, they should be mirrored in planning decisions and other urban processes (Devine-Wright, 2008, 2015).

Human health is clearly influenced by environmental, geographic and social factors. Notwithstanding, people perceive geographical location in terms of named places, which are often vaguely defined and depend on context (Goodchild, 2015) and individuals perceptions (Montello *et al.*, 2003). In consequence, space-related human behaviors, many related to health, are driven by places (Goodchild, 2015) and their multitude of facets, including geographic but also emotive ones. For example, literature identified specific factors such as neighbourhood walkability, less sprawled areas, and quality of parks to be beneficial to human health (Smith *et al.*, 2017; Chandrabose *et al.*, 2019). Although the relationship between the emotive facets of place and human health has been extensively studied (Williams and Kitchen, 2012), we encourage researchers to deeply embrace and interact with technologies typically used in smart city and urban analytics research, such as tracking and monitoring through smartphones, wearables or corresponding location-aware services, to give a new impulse and drive research in unveiling the intricately complex relation between emotion, place and health.

Education and place-based research have a strong relationship. On one hand, from a more spatial perspective, many studies acknowledge the importance of location and land use type (i.e., metropolitan, urban, rural) in tests performance and education quality (Panizzon, 2015; Gordon and Monastiriotis, 2007). On the other hand, students associated socio-economic, social and cultural factors are suggested to be even more influential than location (James, 2001). Place should hereby not be simplified as geographic location, but as a living space-time entity, articulated through different facets and from different viewpoints (Van Eijck and Roth, 2010). Here, emotive facets of place such as place attachment and place meaning can play a crucial role in mobilizing people's place-based identification and sense of place to dynamic learning opportunities (Lim and Barton, 2006), environmental education (Kudryavtsev *et al.*,

2012), and place-based science education (Semken and Freeman, 2008). Unfortunately, such research connecting emotive facets of place and education is scarce. Researchers studying the topic generally acknowledge the difficulty in characterising the multi-faceted, evolving nature of place with respect to individuals and their learning process. Stemming from urban analytics and smart cities, technological advances that substantiate the psychological and geographic theories and models of place, making them explicit and tangible, may provide a further basis for building quantitatively approaches and indicators in education based on individual-place relationship. For example, connected to sustainability, the addition of maps and individuals' spatial knowledge in educational initiatives afford students the opportunity to practice a new form of written and visual communication to preserve oceans and promoting United Nations Sustainable Development Goals (Quinn *et al.*, 2019). In such studies and initiatives, the addition of students' emotive facets of place on top of spatial data would enrich the projects with genuine place-based knowledge and might also help to better understand why certain places have a higher priority when it comes to individual and community actions (Manzo and Perkins, 2006; Acedo *et al.*, 2019).

Government, urban planning, health, and education are just some fields in which we have foreseen a clear benefit in incorporating the emotive facets of place in their scientific method. That is, to embrace the complex, multi-faceted, socially constructed individual-place relationships to update and amend current methodologies and resources in targeted fields of knowledge. This is not an easy task, and depending on how the merge is done, it can lead to unintended effects by narrowing down perspectives based on taking certain assumptions for granted. The criticisms to quantitative approaches in Geography also might apply to this research and be a relevant limitation of the study. However, we want to be clear on that; the current research does not want to postulate or propose how technology might solve all problems in place-based research. Instead, we want to emphasize some technology-based advancements as facilitators for modeling and enriching current traditional place-based methodologies studying the emotive facets of place. This relationship also raises important ethical issues. When monitoring individuals, or collecting feelings or emotions, we are also dealing with ethical and privacy issues that can restrict or even ban the implementation of some technology-based solutions. An exhaustive examination of each scenario becomes mandatory to study the possibilities of actions to be taken, such as: consent forms, data aggregation or geo-privacy (Keßler and McKenzie, 2018), to avoid harming individuals' rights.

5.2 | An illustrative case study

In this section, we present a potential case study to exemplify the role of urban analytics to address the gaps highlighted in Section 3 and discussed in Section 4. We choose human health, from the fields envisioned in the last section, to design our study case. In particular, we present a specific experiment, based on a successful study using an app in mental health (Diaz-Sanahuja *et al.*, 2022), in which participants are patients diagnosticated with a gambling disorder and the targeted emotional places to study are places with potential risk for betting (e.g., casinos, other gambling establishments). For the treatment of this disorder, a location-based ICT system (i.e., smartphone app) is provided to the patients when carrying out the therapy. In brief, part of the treatment consists of a recurrent gradual exposure through medically-guided routes in neighborhoods with gambling establishments. The treatment follows, in this case, the European ethical principles (European Commission, 2018) in which the patient has to sign a consent form with all the specifications of the experiment, data use and privacy. The exposures are always in the same area and are recurrent (once per month), thus allowing to analyze patients' emotional facets of place and the evolution of their disorder over time. This case study does not cover websites and apps that allow online bets and only focuses on physical places susceptible to allow gambling. We assume that the closer patients are to a gambling establishment, the more likely they are to suffer a crisis. This specific scenario will also show how urban analytics help in untangling



FIGURE 1 Representation of the four groups described in Section 4 that uncover potential technology-based facilitators to address the research gaps identified in Section 3. The diagram consists of three layers: (i) A-D represent the four points discussed in Section 4, (ii) BA, AC, CD, and BD illustrate the relationship among the first layer, and (iii) BAD, BAC, ACD, BCD depict the high-level connections. All the elements that constitute the layers are explained in the Section 5.2

a negative individual-place relationship and to better analyse negative emotive facets of place. Figure 1 shows the four groups described in Section 4 and the relationship between them in the three layers described below. In the next sections, we describe all the components that constitute Figure 1.

5.2.1 | Layer 1: technology-based facilitators to improve patients' treatment

A: Multi-source urban data. The multi-source data acquisition is crucial for a better understanding of the patients' surroundings. Free open APIs⁴ about the weather, urban morphology (e.g., Open Street Maps (OSM), governmental sources), and others that require to obtain credentials such as Twitter provide valuable information to contextualise patients-place relationships. For example, OSM allows locating the casinos and gambling establishments, and add them in the app used to monitor patients' emotions when approaching. Other governmental sources of data can provide urban topographic models, and third parties such as Twitter permit to find past, present and future events, such as sports competitions, which might influence betting tendency and behaviour.

B: Real time in situ approaches. ESM techniques, smartphones and wearables create a suitable scenario to obtain a better overview of patients' emotive facets of place in real time. For example, surveys facilitate the perceptions of the patients during the exposure therapy. This information can be enriched and extended with objective data from paired wearables (e.g., heartbeat) and contextualized by the inertial sensors from the smartphone, such as gyroscope and accelerometer. Moreover, the flexibility of a smartphone app allows for personalized functionalities such as a panic button to call patients' therapist. Patients will then be monitored providing crucial information about their emotive facets of place during treatment and the app provides customizable ways for clinicians to operate in the event of a

⁴ for an exhaustive list of free open APIs check https://github.com/public-apis/public-apis accessed on 5 May 2022

possible emergency.

C: Temporal coupling. Longitudinal studies about the emotive facets of place can be used to analyze the evolution of the patients' disorder. The expositions during the treatment of the patients, joinlty with different urban data, and patients' responses to surveys and actions, can be stored for the clinicians to have access to detailed information over time. Patients' perceptions and feelings are as important as any significant change in the urban context. Clinicians, possibly supported by IT services, must deal with the management, maintenance and modeling of the database and its stored records. These tasks play a critical role in covering crucial features for patients' treatment and in the analysis of their emotive facets of place.

D: Capturing the dynamic spatial dimension. The spatial representation of a place-influenced disorder also affects how to read the patients' emotive facets of place and when to trigger medical actions. The GPS in our smartphones, wearables and other sensors geo-located in the urban environment can record the location of the patients and, therefore, their route. Any spatial calculation, spatial buffer or location-based surveys requires geolocated data to trigger the action through the app. Patients' location is a crucial resource for a medically-guided exposure treatment. For example, patients' position when approaching a casino can unleash a sequence of notifications, warnings and suggestions to prevent the patients from an exposure to a likely dangerous situation and activate an undesired negative emotional attachment (Mennis and Mason, 2016).

5.2.2 | Layer 2: combining technology-based facilitators in patients' treatment

BA: Real time in situ approaches and Multi-source urban data. Combining urban and objective/subjective information from patients allows clinicians to contextualise patients' movements, directions, and feelings. An unexpected change in the direction of patients can imply that they got eye contact with a gambling establishment. This possible scenario can be analysed by locating patients, direction and transportation mode in a topographic model with all potential places for gambling. A basic (course-grained) event analysis of social media feeds geo-tagged in the exposure zone could provide further information on possible events prone to gambling (e.g., sports events). Furthermore, objective data from wearables (e.g., heartbeat) can confirm any disruptive change in the subjects' mood and trigger real time recommendation from the clinicians.

AC: Multi-source urban data and Temporal coupling. Any update about the place where the treatment is running and possible future events needs to be covered and revised for future medical decisions. A system detecting urban environment changes (e.g., a temporal database, analysing city news feeds, or others) and a database of patients' records is extremely valuable to automatically detect important changes, safer days or locations to run future exposures, and statistically assess the patients' evolution over time. For example, the proximity of a casino may totally change patients' salience of place (personal view) (Obaid S. Almuzaini, 2017) and be a potential reason to reconfigure the exposure process. Moreover, a mere connection to weather forecasting or expected traffic conditions within the app can help in predicting quiet and safer days for the exposure.

BD: Real time in situ approaches and Capturing the dynamic spatial dimension. An integrated system in the app must connect the real time subjective and objective records from patients and the spatial representation of a placebased disorder. The repetitive exposure of patients to unsafe places regarding their disorder also influences the spatial dimension of patients' disorder and related emotive facets of place. Tracking their location and emotions, along with on-site surveys, allows continuous monitoring of the spatial dimension of patients' emotive facets of places such as place attachment (Scannell and Gifford, 2010) and place identity (Vanclay, 2008). For instance, simple questions about patients' emotions (e.g., "How do you feel?") when approaching a gambling establishment plus information revealed by wearables (e.g., smartwatch) can define and record the spatial extension of the spatial value (Quesnot and Roche, 2015) related with the disorder.

CD: Temporal coupling and Capturing the dynamic spatial dimension. Longitudinal studies about the spatial dimension of the emotive facets of place are important to analyze patients' perceptions of the disorder geographically. The retrieval and update of spatial information regarding place-based emotions such as sense of place and place attachment incorporates a dynamic spatial understanding of the disorder. This can be understood as a dynamic spatial buffer that hopefully is decreasing its extension as long as the treatment is evolving. For example, as a consequence of the treatment, patients' negative sense of place (Tuan, 1978) towards a casino must become neutral over time while patients' place dependence level (Vanclay, 2008) should decrease gradually as well as its spatial dimension. With this valuable information, and in-session notes, clinicians in charge of the treatment can evaluate the exposures and reconfigure spatial aspects of the instructions given to the patients such as new routes to follow and activities to perform in certain places.

5.2.3 | Layer 3: high-level take-aways for patients' treatment

BAC: Patients' environment provides real time informatinon of patients, urban data and longitudinal records to analyse, decide and evaluate the emotive facets of place and, therefore, patients' evolution.

BAD: Geographical environment enables an overview of the different geographical and contextual features (e.g., unsafe locations and events, secure paths) and how they can influence or model patients' disorder.

ACD: Dynamic urban spatial context allows a better understanding of the influence of urban infrastructure and sociocultural context on the patients' disorder over time.

BCD: Patients' spatial context permits the study of patients' emotive facets of place concerning disorder's spatial footprint. It allows the control of the spatial variability of the emotive facets of place over time.

6 | CONCLUSION

This study has investigated the identified gaps in the emotive facets of place research through the opportunities that offer technology-based advancements in urban analytics. First, we discussed how existing platforms and tools in urban analytics (e.g., GeoEnrichment, SocialGlass) can improve the acquisition of multi-source urban data to better contextualize the emotive facets of place. Second, we highlighted how the combination of subjective (e.g., ESM) and objective (e.g., sensor measurements) measures produces more reliable data and becomes essential to have a better overview of the emotive facets of place in real time. Third, we illustrated some solutions (e.g., databases' types, programming models, stream processing extensions), already implemented in data-driven studies, that can help with coupling emotional experiences and location over time and individuals' life courses. Fourth, we mentioned novel methodologies using different sources of information (e.g., wearables, smartphones) to capture the dynamic spatial dimension of the emotive facets of place. Fifth, we also contribute to contextualizing the emotive facets of place in a more general empirical and theoretical discussion in government, urban planning, health, and education. Finally, we present an illustrative case study to exemplify the role of urban analytics to address the identified gaps in the emotive facets of place literature in the context of a mental health scenario. The possibilities to scale-up methodologies from (spatial) data-driven fields of knowledge and embed them to disciplines that examine place-based concepts can (i) enrich and enhance current data-driven research questions, by recognizing and linking the essence of the place-based geographical perspective, and (ii) provide guidelines and insights for methodical ways to collect, manage, and analyze place facets in sociological studies.

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