



Crowdsourcing affective responses to space

Erfassung affektiver Raumwahrnehmung durch Crowdsourcing

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Abstract

Humans perceive and evaluate environments subjectively. These interpretations influence daily behavior and decision-making in space. Recently, due to the ubiquitous availability of smartphones and the increasing growth of Web 2.0, crowdsourcing is emerging as a promising approach for collecting and modeling people's affective responses towards space. In this paper, we illustrate how these affective responses can be crowdsourced, and how these collected datasets can help to study the impact of environmental characteristics on people's affective responses, as well as how these responses differ among people with different characteristics, background, and contexts.

Keywords: emotion mapping, crowdsourcing, subjective geo-information, human-environment-interaction

Zusammenfassung

Der Mensch erlebt und bewertet seine Umwelt. Derartige Interpretationen beeinflussen Entscheidungen und Verhalten des Menschen im Raum. Durch die gegenwärtige Nutzung von Smartphones und den zunehmenden Wachstum des Web 2.0 werden neue Möglichkeiten geschaffen, um derartige affektive Bewertungen des Raumes zu erfassen. Crowdsourcing erweist sich dabei als vielversprechender Ansatz. Dieser Beitrag veranschaulicht, wie affektive Raumdaten mittels Crowdsourcing erfasst werden können, und wie derart erhobene Daten in weiterer Folge genutzt werden können, um die affektive Wahrnehmung der Umwelt in Abhängigkeit von raumbezogenen und personenbezogenen Eigenschaften sowie kontextuellen Bedingungen zu erforschen.

Schlüsselbegriffe: kartographische Darstellung von Emotionen, Crowdsourcing, subjektive Geoinformation, Mensch-Raum-Beziehung

1. Affective responses towards space

To a large extent, daily behavior and decisions in space are influenced by an individual's affective interpretation of the environment. This is due to the fact that stimuli and environments are perceived not only according to physical features, but also subjectively – in terms of a person's affective response towards them. According to Russell (2003) some affective response is always present within a person, either perceived as neutral, moderate or extreme. When affect is moderate or extreme, it can be consciously experienced as pleasant or unpleasant and form the basis of an emotional experience (Barrett et al., 2007; Russell, 2003). When affect is milder, it influences conscious experience and behavior in a less direct way. In this case, affect is experienced in the background – as property of the environment (Russell, 2003; Barrett et al., 2007). These two affective states – emotions and affective qualities of the environment – are common approaches for investigating affective responses to space. However, emotions are multifaceted phenomena and difficult to study. Due to their complexity and connection with other processes, there is no agreed-on

definition or method to clearly indicate and mark off emotions from other affective states, such as mood or feelings.

Another way to study affective responses to space is by examining affective qualities of environments. Affective qualities are experienced as properties of the external world, commonly described with affect-denoting adjectives such as hectic, exciting, or beautiful. These affective qualities are verbally attributed to a place, but have the ability to change a person's affective feeling of pleasure or displeasure (Russell & Pratt, 1980; Russell, 2003). According to Russell (2003), the perception of affective qualities is a ubiquitous process. People evaluate and judge their surroundings routinely, at any time, whereas emotional experiences are rather infrequent, triggered by intense or situational cues (Myrtek, 2004). A number of studies in the field of environmental psychology indicate effects of environmental characteristics on wellbeing (Ulrich, 1984; Kaplan, 1993; Hartig & Staats, 2006), satisfaction (Hur et al., 2010), and on behavior in space. Such behavioral changes involve changes in the kind of social interaction in space (Sullivan et al., 2004), perceived walkability of space (Leslie et al., 2005), as well as the choice for walking routes (Zacharias, 2001; Borst et al., 2008). Data about people's preferences and avoidances of environments may be used in various fields of research - one of which is navigation. Borst et al. (2008) studied route choices of elderly people in relation to environmental attributes. Their findings suggest that people do not simply decide for the shortest route, but that decisions in space are influenced by various characteristics of the environment, such as parks, slopes, trees, front gardens, or shops. Consequently, data about people's perception of space may be used to better predict people's route choices, and support spatial behavior in a user-oriented way (Borst et al., 2009).

In this paper, we will illustrate how crowdsourcing can be used to collect people's affective responses towards space, and how these affective data can be used to study how people perceive and interact with environments differently.

2. Collecting affective responses towards space

Affective responses towards space can be collected through various approaches (see Griffin & McQuoid, 2012 for an extended review). Self reports and physiological recordings are among the most prominent conventional methods for collecting such data. However, these approaches are traditionally situated in rather artificial conditions (in laboratories with highly controlled conditions, or have participants equipped with unhandy devices). Due to recent developments of new technologies, novel methods and sources of data have become available for collecting affective responses towards space. In the following we will describe some of these current approaches.

2.1 Psycho-physiological recordings

Sensors for collecting affective responses are becoming smarter, smaller and easily wearable in space. Physiological recordings through these sensors (e.g. galvanic skin response, electrocardiogram) provide an objective measure to affective responses gathered in space (Bergner et al., 2012; Hogertz, 2010). Affective responses are indicated by a person's high or low arousal (e.g. high arousal as an indicator for stress), with the advantage that users do not even need to recognize and label physiological changes themselves. However, interpreting these data is quite challenging, since high arousal may or may not be related or caused by emotional experiences.

2.2 Self reports

When affective data are collected through self reports, affective experiences are consciously named and labelled by respondents. Such responses are subjective by nature, with the advantage of approaching a person's subjective experiences, interpreted by the individual, and expressed in his/her own words. However, it may be difficult for some people to label affective experiences. Culture and language shape an individual's emotional vocabulary (Wierzbicka, 1999), but also inter-individual differences on higher or lower emotional granularity (Barrett et al., 2007). People high in emotional granularity represent mental contents in addition to valence (pleasure-displeasure), whereas those low in granularity represent their experiences primarily as feelings of comfort (Barrett et al., 2007). Taking into account these challenges, self-reports studies on affective responses must be adapted to individual competences and be designed carefully.

Conventional methods for affective responses through self reports, are often rather extensive, time-consuming, and laid out in rather artificial settings (e.g. in laboratories with highly controlled conditions). However, within the last several years, online social networking websites and new technologies have been developed rapidly, and many users start to express their affective responses or comments towards space online. This opens new leads for gathering self-reported data.

2.3 Social media and Crowdsourcing

Due to the development of online social networking websites, recent research attentions have been drawn to mining social media data to study people's affective responses to space. Techniques on natural language processing are often employed in these approaches for analyzing social media data. For example, Mislove et al. (2010) extract the mood of people from different cities by mining information on social media, i.e., tweets. This information is related to various places (e.g. states), but is not collected as responses towards space. However, there is also some recent research on mining affective responses towards space from social media. For example, Tauscher and Neumann (2012) generate sentiment maps of touristic locations, by mining online tourist reviews. Hauthal and Burghardt (2013) extract location-based emotions from photo titles, descriptions, and tags of Flickr and Panoramio photos. However, it is important to note that data on social media are often noisy and multilingual, and processing these data are still quite challenging. More importantly, this approach often fails to collect affective responses from heterogeneous groups of people. Moreover, affective responses from these sources may not be easily linked to the physical environment.

Recently, due to the ubiquitous availability and use of smartphones, and the rapid spread of Web 2.0, researchers start to explore using smartphones to capture users' self-reported affective responses. With smartphones a large number of users can be reached and data can be collected in real-time, real scenarios, anytime and anywhere. In this crowdsourcing approach, data can be collected in a high granularity in space, and be automatically linked to the physical environment. Due to these advantages using mobile phones for reporting subjective information appears to be a very promising approach for gathering location-based subjective data, directly, efficiently, and in real-time.

Research has started to focus on developing mobile services, to gather users' wellbeing and feelings and to relate them to the geographic reference of their occurrence. The research project "Mappiness" is among the most prominent of such mobile applications, aiming at studying people's happiness in relation to the local environment (MacKerron & Mourato, 2011). In particular, users are asked to rate

how happy, relaxed, and awake they are as well as for additional contextual and situational information (e.g. current company, activity). The users' location is stored automatically. This allows for subsequently linking users' ratings to characteristics of the environment. The research project "Track Your Happiness" (Killingsworth & Gilbert, 2010), aims at investigating causes and correlates of happiness. This research studies factors that affect people's happiness in their daily lives. Information is gathered (on a webpage or via smartphones) about a person's current wellbeing ("How do you feel right now?"), and related to current activities, indoor or outdoor locations, company, time of day, etc. However, in this project location is not obtained from a geographic position, but refers to the situations or contexts users are in (e.g. at work, at home, in a car).

Present location based services for collecting affective experiences in space tend to focus on various affective states of the users in relation to space. However, these services do not necessarily gather experiences *caused by* environments. Whether the feelings reported are attributed to or even evoked by environmental factors, remains unclear. To get more distinct data on this issue, it may be necessary to ask the user more specifically of how the environment makes a person feel, instead of asking "How are you?", or as Russell (2003) suggests, directing people's attention to their surroundings by having people evaluate their environment.

3. Visualizing affective data

Affective data allow researchers to gain insight into people's experiences towards space. Visualization plays a key role in this. Different techniques are often employed to visualize affective data, such as dot maps, choropleth maps, cartograms, and interpolated maps. Dot maps are usually used if the data for visualization are point features, such as affective responses which are collected as a set of point-based data. In dot maps, it is important to ensure that the dot is represented in its correct spatial location. In contrast, choropleth maps use area symbols to depict the data. For visualizing affective data with choropleth maps, different observations or recordings can be aggregated to enumeration units, such as administrative boundaries. White (2007) provides an example of using choropleth maps to visualize a "map of world happiness". Similarly, cartograms are also used for mapping affective data. In cartograms, the geometry of each enumeration unit is distorted/scaled to reflect the variable (e.g. population) being mapped. Mislove et al. (2010) use cartograms to visualize the mood in the USA extracted from Twitter messages (tweets). The area of each state is scaled to be proportional to the number of tweets that originate from the state. In contrast to the techniques described, interpolated maps consider affective responses to space as continuous phenomena, and visualize affective data as a continuous surface or layer. Interpolation is a method of finding the value of an unknown point according to a known set of discrete data points. Estimating the value of an unknown point can be achieved with different interpolation algorithms, such as Inverse Distance Weighting (IDW), Kriging, bilinear and cubic convolutions. Interpolated maps can be used to effectively visualize the spatial distribution patterns of emotions (affective responses). Jang (2012) shows an example on this, by using IDW to interpolate and visualize different emotions on a 3D map.

4. The EmoMap project - Crowdsourcing-based emotion mapping

Environmental features are perceived and evaluated subjectively by individuals. Such evaluations may influence a person's behavior and decision-making in space. Hence, with the project EmoMap

we aim at gathering people's affective responses to space through mobile phones, as well as at modelling, and visualizing these data, which can then be incorporated into geospatial services and applications, particularly into navigation services for pedestrians.

In general, the affective data collected in this study allow for the investigation of people's evaluations of space. At an individual level, these data can be used for studying similarities and differences of experience and interpretations of space between individuals and within individuals. The data can also be aggregated to study the impact of environmental characteristics on people's affective responses, as well as how these responses differ among people with different characteristics, and in different contexts. All these contribute to a better understanding of human-environment interaction, as studied in the disciplines of environmental psychology, geography, urban planning, and architecture.

As a result, the affective data can be aggregated to provide smart location based services (LBS). For example, affective data can be aggregated to produce collective emotion maps in mobile city guides for showing places of interest or unsafe places of a city. This layer of subjective information may enhance people's experiences while exploring a city (e.g. tourists). Mobile pedestrian navigation systems can also benefit from affective data. Golledge (1995) shows that pedestrians – especially when having enough time – favour different route qualities, such as safety, attractiveness, and convenience, over shortness. These additional route qualities are subjective by nature and thus difficult to measure and model with geometrical characteristics of the road network (Huang & Gartner, 2012). However, aggregating affective data may be a promising approach to model such subjective route qualities. For example, if similar users in similar context consider a specific place as attractive, probably this place can be also viewed as attractive for the current user in the current context. Therefore, smart routing services can be provided in LBS by aggregating affective responses from similar users in similar context.

In the following section, we will particularly focus on collecting affective data, and how these data can help to study the impact of environmental characteristics on people's affective responses, as well as how these responses differ among different groups of people.

4.1 Emotion-Space-Model

As a first task, an emotion-space model has to be laid out, aiming at making subjective data about space easily reportable. Watson and Clark (1992) propose a hierarchical model, with two levels of affective experiences: a higher order affect-dimension of valence (e.g., negative or positive affect) and a lower order level of affective categories, which reflect specific contents of affect (e.g. fear, anger, stress, etc.). In line with Watson's and Clark's model, and due to the fact of individual differences regarding the ability to characterize affective experiences as broad versus discrete terms, a hierarchical structure for collecting affective data in space was opted for this study. On the high order level of this model, people's level of comfort in space is gathered, whereas on the low order level, users can optionally report more specific content regarding their affective experiences in space:

1. Level of comfort: According to Wierzbicka (1999) and Barrett et al. (2007) the level of comfort can be easily perceived and reported by any person, independent of culture, language, emotional vocabulary and granularity or age. Consequently the level of comfort in a given environment is used as the basic level for gathering space-related affective data. In particular, we ask the participants to rate their level of comfort in the environment they were in: from comfortable to uncomfortable, on a 7-point Likert scale.

2. Level of distinct affective environmental qualities. In a second step, we ask the participants to rate affective qualities of the current environment (Figure 1). The affect-denoted parameters used in this project were obtained in a multistage method in several iterations: 67 affect-denoted environmental parameters were compiled by participants of a focus group (N=9), reduced in online questionnaires to 12 parameters (N=102), and further aggregated through factor analysis to four affect-denoted terms (safety, attractiveness, diversity, and relaxation). These four factors are used in the emotion-space-model of this study. In particular, participants are asked to rate their surroundings on a 7-point Likert scale, regarding safety (unsafe-safe), attractiveness (unattractive-appealing), diversity (monotonous-diverse), and relaxation (hectic-calm).

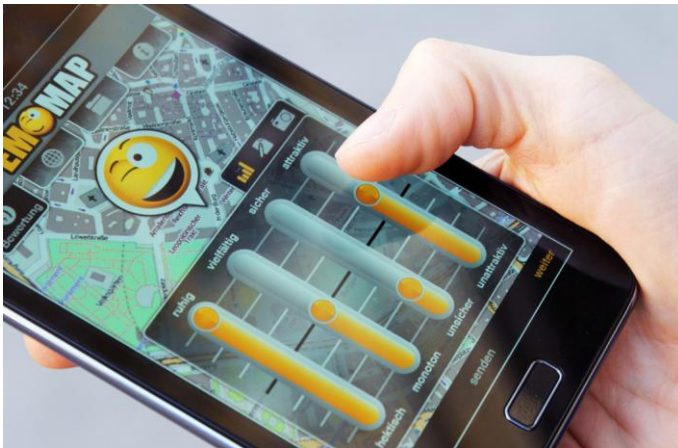


Figure 1: Screenshot of the Android application for collecting affective responses in space.

4.2 Data collection

Due to the ubiquitous use of smartphones and the increasing growth of Web 2.0, we collected affective geographic data via crowdsourcing – from people using their smartphones to contribute data. Based on the Emotion-Space-Model, a mobile application was set up to enable people to report their affective responses towards space anytime and anywhere. The application (working on smartphones with Android 2.1 or above) was available in English and in German and could be downloaded for free from the project website. Due to GPS positions being automatically matched to OpenStreetMap, data could be contributed without spatial restrictions.

With this crowdsourcing approach, we are able to acquire subjective data directly from the users – without further retrospective interpretation needed –, reported in a high granularity in space, and automatically linked to the physical environment. The approach aims at a direct, efficient, real-time collection of data, evoked by realistic scenarios, leading to high ecological valid results.

4.3 Results

In total, until January 31st 2013, 2178 contributions were collected from 125 people (72 female vs. 53 male). The contributions are distributed in Austria, Germany, Switzerland, Czech Republic, Slovakia, Slovenia, and China. However about 97% of the contributions are for the city of Vienna, Austria. For analysis, we selected a particular area around Vienna University of Technology with 473 contributions from 79 participants.

In order to visually compare people's affective responses towards urban space, we depict these affective responses with interpolated maps for each urban setting. For interpolation, we use the IDW method, which is an effective way to visualize the spatial distribution patterns of emotions (affective responses) (Jang, 2012). IDW estimates the value of an unknown point as a weighted average of the neighboring known points, while the weights are assigned as the inverse of the distance to each known point.

4.3.1 The impact of environmental characteristics

In order to study the impact of environmental characteristics on people's affective responses, we subdivide the area into three distinctive urban scenes according to their level of traffic and vegetation: A) green urban area (urban-green), B) urban area with light or no traffic (pedestrian lanes and one-lane street, urban-light traffic), and C) urban area with heavy traffic (roads ranging from two to three-lanes, urban-heavy traffic) (see Figure 2). The selected area is characterized by mainly five-storey houses, built around 1900. These three urban scenes are compared according to the participants reported level of comfort, safety, diversity, attractiveness, and relaxation. The results suggest that the ratings significantly differ between the three environmental settings regarding all affective parameters: comfort ($H(2)= 103.4, p < 0.001$), safety ($H(2)= 24.9, p < 0.001$), diversity ($H(2)= 16.3, p < 0.001$), attractiveness ($H(2)= 68.3, p < 0.001$), and relaxation ($H(2)= 90.2, p < 0.001$).



Figure 2: Level of comfort according to three urban scenes (from left to right: green urban area, urban area with light or no traffic, area with heavy-traffic. (Streets and houses by © OpenStreetMap-Contributors, CC BY-SA.)

In general, urban green areas show the most positive ratings between the three urban scenes in any of the affective parameters, followed by areas of urban-light traffic. Urban areas with heavy traffic, on the other hand, show highly negative ratings (particularly relaxation: $M= -1.74, SD= 1.12$; comfort: $M= -0.62, SD= 1.47$; attractiveness: $M= -0.61, SD= 1.69$) (Figure 3).

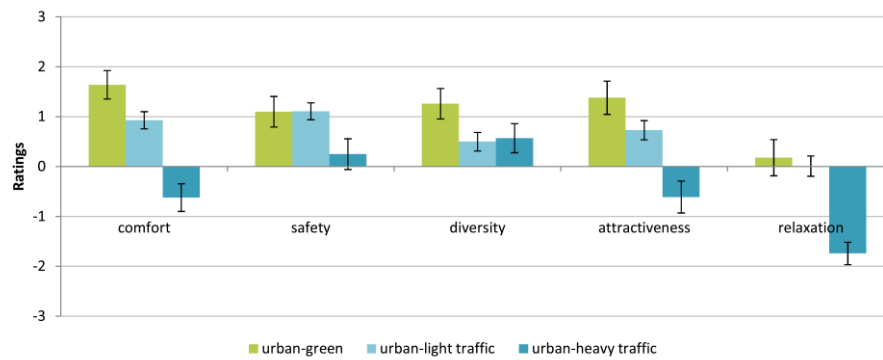


Figure 3: Affective responses to space according in three environmental settings. The bars represent mean values, with a confidence interval of 95%.

4.3.2 The impact of individual characteristics and context

Individual, situational, and contextual factors can affect people's experiences of space. In order to exemplarily study the impact of individual characteristics, backgrounds and contexts on people's evaluation of space, we analyzed the effect of company at the time of contribution, a person's familiarity with the area, and gender.

Company: 227 contributions (48 %) were reported by participants in company, and 246 contributions (52%) were reported from people in no company. In this study, company had a highly significant effect on the perceived level of comfort ($U= 23741$, $p= 0.004$). People in company showed significantly higher levels of comfort ($M= 0.89$, $SD= 1.64$), than people who were alone ($M= 0.52$, $SD= 1.6$) (Figure 4). However, company showed no significant effect on the other environmental qualities of safety, diversity, attractiveness, and relaxation (Mann-Whitney-U-Test, with a significance level of $p < 0.05$).



Figure 4: Level of comfort according to participants in and without company. (Streets and houses by © OpenStreetMap-Contributors, CC BY-SA.)

Familiarity: 358 (75.7%) ratings were contributed at familiar places, whereas 115 contributions (24.3%) are ratings at not familiar places. The levels of attractiveness (see figure 5) and diversity (see figure 6) differed significantly between people who visited the area for the first time and those who were familiar with it (attractiveness: $U= 17865.5$, $p= 0.03$; diversity: $U= 17816.5$, $p= 0.03$). Participants who were familiar with a place reported the environment to be more attractive and more diverse than first-time visitors.

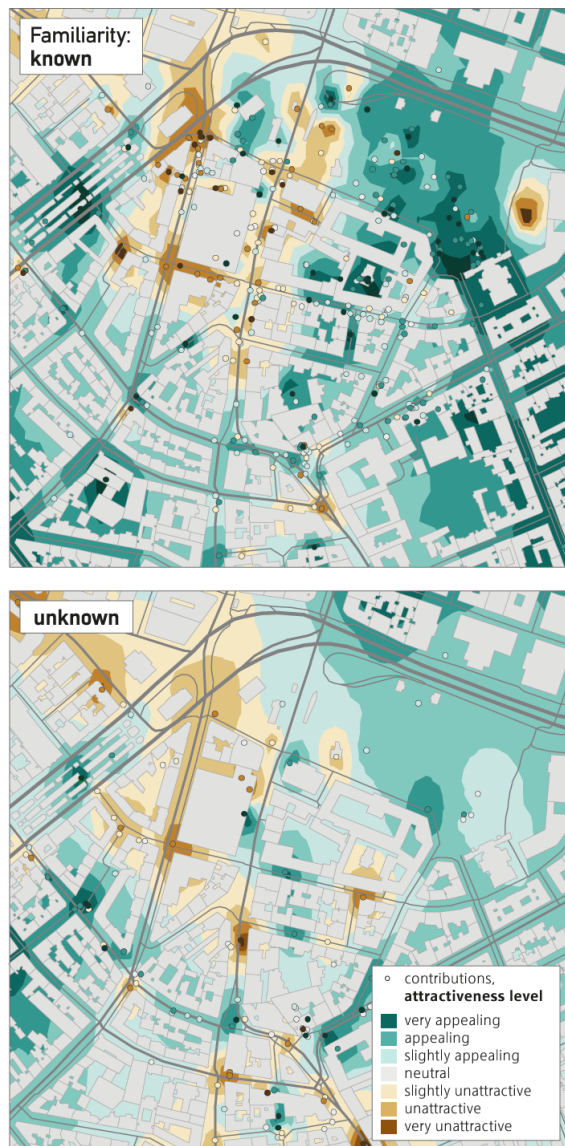


Figure 5: Reported levels of attractiveness of participants familiar and unfamiliar with the area. (Streets and houses by © OpenStreetMap-Contributors, CC BY-SA.)

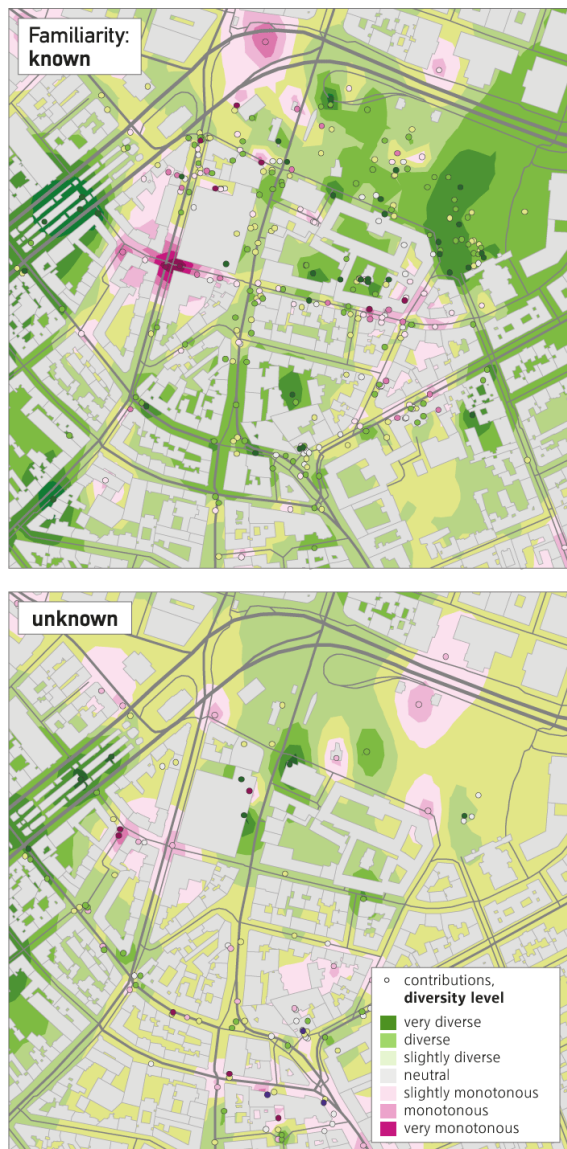


Figure 6: Reported diversity of participants familiar and unfamiliar with the area. (Streets and houses by © OpenStreetMap-Contributors, CC BY-SA.)

Gender: In total 257 contributions from females (54.3 %) and 216 contributions from males (45.7%) were collected. The results indicate no significant influence of the participants' gender regarding the reported levels of comfort, safety, diversity, attractiveness, and relaxation (Mann-Whitney-U-Test, with a significance level of $p < 0.05$).

4.4 Discussions and implications

The findings indicate that environments varying according to the amount of vegetation and traffic are perceived differently. Affective responses differed significantly in all three environmental settings, with highest positive ratings for the urban-green area, and lowest ratings in the heavy traffic urban area. These findings are in line with pivotal research, suggesting green, natural settings to be preferred and rated more positively over built and heavy traffic environments (Hartig & Staats, 2006; Van den Berg et al., 2007; Ulrich, 1986).

We also showed that not only physical characteristics of the environment lead to different experiences, but also that context (e.g. company) and familiarity influence an individual's perception of space. Familiarity as an influencing factor in evaluative judgments has been found in many pivotal research (for an explanation of this phenomenon see Zajonc, 1968). In this study gender did not have a significant influence on the perception of space. However, it is important to note that the participants of this study were mainly students, and therefore a rather homogenous group. Hence, gender differences in the evaluation of space may be prevalent in a different, more heterogeneous sample. At this point it is also worth noting that the parameters analyzed in this study do not claim to be exhaustive. Rather, it shows an excerpt of possible environmental, individual, and contextual factors which may influence people's affective responses to space. Other factors, such as temporal environmental conditions (e.g. weather), contextual factors (e.g. purpose of walk), mood congruency (Mayer et al., 1992; Forgas, 1995), and personality (McCrae & Costa, 1992; Gallagher, 1990), may also influence evaluative judgments. Considering these parameters will help future studies to obtain even more realistic and differentiated results.

Even with this rather homogenous group of participants, the results suggest that different urban spaces evoke different affective experiences. Therefore, it can be expected that more significant differences would be observed with heterogeneous groups of participants. As shown in literature, daily behavior and decisions in space are influenced by these kinds of affective responses (Borst et al., 2009; Sullivan et al., 2004; Coley et al., 1997). Therefore, in order to offer services that more adequately support and suit users' needs and preferences, geospatial applications, especially LBS, need to pay attentions to both the objective attributes of locations and people's subjective perception of space. As mentioned before, in a next step, we will try to collect more affective data from different kinds of people, and incorporate these affective data into mobile pedestrian navigation systems – one of the most popular LBS applications – to provide emotion-aware route planning for pedestrians. Another implication taken from the above data analysis, is that affective responses should be modeled not only in respect to where they refer to, but also in which context they are contributed, e.g., company (with others vs. alone) and familiarity (first time visit vs. return visit).

5 Summary and outlook

In this paper, approaches on modeling, gathering and visualizing these affective responses have been discussed. As an illustration, we showed how these affective data can be crowdsourced and used to answer the questions of “how are different types of environments perceived differently” and “do people with different characteristics and background perceive the environment differently”. However, applications of the affective data will not be restricted to this. Currently, we are working on aggregating the collected data to enhance pedestrian navigation systems with more satisfying routing services.

Until February 2013, the number of affective contributions is steadily growing. For a comprehensive understanding about how environments are perceived by different groups of people, more data from heterogeneous groups of participants must be collected. Currently, we are studying how to encourage different groups of people to actively participate in the EmoMap project. Relevant literature (Kim, 2000; Budhathoki & Haythornthwaite, 2012), as well as experiences and strategies from successful Web 2.0 websites such as Foursquare, Facebook and Wikipedia will be analyzed and adapted to achieve this aim.

With the increasing number of available affective responses, a subjective layer aggregating these affective responses can be overlaid on top of the existing objective geospatial data. This subjective layer brings many opportunities not only to gaining insight into how people interact within and experience environments, but also to smart and innovative human-centered ICT (Information and Communication Technology) applications, and as valuable basis for decisions for planning and community-oriented measures in space.

It is important to note that, currently, we collected this affective information as point-data, i.e., affective data automatically annotated with GPS locations. While this approach frees the user from manually reporting her/his location and thus facilitates the way of contributing, it also faces some challenges, such as poor GPS accuracy in urban settings and ignorance of the fuzzy nature of the location component. Research on fuzzy theory and place modeling should be combined to address these challenges. We will investigate this issue in a follow-up project.

Acknowledgement

This paper is part of the research project EmoMap, which is funded by the Austrian Ministry of Transportation, Innovation and Technology (BMVIT), managed by the Austrian FFG, within the strategic program iv2splus.

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