

Humans as Sensors to Enhance the Built Environment: a Case Study of the Eastern Harbor, Alexandria, Egypt

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1 ABSTRACT

Good urban design is not about how places look like, but rather about the art of making places for people and creating public spaces that work for the whole community. Urban spaces suppose to be designed for pedestrians and are expected to fulfill their needs. Therefore, it is of great importance to receive the users' feedback and response in order to tailor our designs to suit them best. However, it is not always quantitative data that explains the user's interaction. Hence, this research focuses on making use of emerging technologies within the field of urban planning to efficiently collect and visualize qualitative data rather than only quantitative data. This happens in pursuit of enhancing the living conditions in our cities, which is the main goal of every planner, developer, politician, and citizen.

This research is investigating a new method of measuring how people feel in their city and how they react to the surrounding built environment with the help of using "SMART-Bands". These devices can measure body parameters in real-time, like skin temperature, skin conductance and heart rate, as indicators for human emotions. This collected data is used to interpret how humans feel and react towards the availability or lack of different urban elements within any studied area.

This paper experiments with those "SMART-Bands" to analyze one of the frequently used paths in the city of Alexandria, the Eastern Harbor. It is a major destination for Alexandrians all year long and during all 24 hours of the day. It represents a substantial recreational facility, as well as hosts a lot of civic and recreational buildings. The two sides of this path have relatively different appearance, pavements, and landscape elements.

The presented paper investigates how people react to those two sides of the same path and tries to link this feedback to the presence or absence of urban design elements and street conditions along that path. It is a pilot study for a more thorough analysis for involving users and their feedbacks - both qualitative and quantitative - to enhance the built environment of major urban areas. That helps re-mixing the city according to pedestrians' needs.

2 INTRODUCTION

Nowadays, the design of urban spaces has got a lot of interests from urban planners as it is the art of making places for people. A foundation with several concepts, theories, and methods that work on the relationship between the built environment and physical activity has been provided and used by urban planners (Susan L. Handy, 2002). Humans often reproduce their experience, so they assume that "things as they are" cannot be changed. Despite the fact that humans accept the world as it is, the community has a remarkable capacity to plan ahead, shape the future, and adapt to new settings (Jackson, 2003).

On the other hand, the built environment for pedestrians has attracted both planners and public health officials promoting policies that improve its quality through mixed land uses, interconnected street networks, sidewalks and other facilities. A growing number of experimental studies have contributed to the debate about the relationship between the built environment and pedestrian behavior (Cao, Handy, & Mokhtarian, 2006). Susan L. Handy (2002) augmented that a combination of urban design, land use patterns and transportation systems that promotes walking and cycling will help to create active, healthier, and more livable communities.

According to Landis, et al (2001), there are several pedestrian models that consider the statistically significant roadway and traffic variables, which describe pedestrians' perception of safety or comfort. Still, a method is needed to objectively quantify this perception in the roadway environment.

There is general consensus that pedestrians' sense of safety and comfort within a roadway corridor is based on a complex assortment of factors, such as personal safety, architectural interest, pathway or sidewalk shade, pedestrian-scale lighting and amenities, presence of other pedestrians, conditions at intersections, etc.

All these factors that physically affect pedestrians throughout the built environment still need more studies on the statistically reliable impact on pedestrians' feelings and perception.

3 OBJECTIVES

Improving the quality of life in our built environment is the focal point of every planner, developer, politician, and citizen. This research focuses on making use of emerging technologies within the field of urban planning to efficiently collect and visualize qualitative data rather than only quantitative ones.

The presented study aims to test the usefulness of “SMART-Bands” to sense and chart pedestrians' perception within urban spaces. In spite of the non-representative size of the test sample, this study highlights potentials and limitations of such a tool and technique for aiding urban decision makers. If proven useful, more elaborate studies with bigger sample sizes can be planned and implemented.

This paper presents a sub-study of a wider research that aims at answering the following questions: how do people perceive their environment? How is it possible to collect all of the citizens' impressions in a centralized way and how could these qualitative impressions be visualized?

4 METHODOLOGY

The carried out test tracks the stress responses of two participants while walking on both sides of El-Geish Promenade of the Eastern Harbor in Alexandria. While both sides present different urban settings, the study investigates how this influences pedestrians' perception.

4.1 Emotion measurement with physiological vital data

This paper aims to make a contribution to a new method of measuring how people feel in their city. Peoples' feelings and affective emotions are tightly connected with the individual perception. In turn, this perception is linked with the actual surroundings, be it the build environment, pedestrians around or other influencing factors, i.e. traffic or noises. This raises the question how these feelings and emotions, influenced by the individual perception, are objectively measured and brought together with the environment. First, a better understanding of emotions is needed.

Based on previous research in the new field of Affective Sciences (NFS Affective Sciences, 2011) and classical emotion research, emotional reactions are reflected in changes in the activity of the autonomic nervous system. As a result of this activity, specific physiological parameters (e.g. skin conductance and skin temperature) show different values depending on the actual emotion (Kreibig, 2010). These parameters are classified as vital data of the individual. In this context, the so-called method of the psychophysiological monitoring implies the recording of objective vital data in real-time and for every instant. With the help of this data, unswayed affective emotions are derived. In the research at hand, especially mental load (stress) in context with the actual surroundings is observed. Stress can be understood as a product of anger and fear, both considered as highly negative emotions (Bergner et al. 2011).



Figures 1 and 2: The Physiological Stress Reaction (Bergner et al. 2011) and the SMART-Band (own source)



Figure 3: The Study Area with Street Sections along the Path

A negative emotion is given, when the skin conductivity increases and shortly afterwards, the skin temperature drops (Bergner et al. 2011). The following graphical curves illustrate this process (Figure 1). The slope values of the curves can be used for statistical analysis. The mathematical function of these parameters and their curves is simplified with the first derivation. The method of using scoring points (increase in skin conductivity = Scoring +1; decrease in skin temperature = -1) was previously used in several studies (Bergner et al. 2011). In the research at hand a new technical device, the sensor wrist-band

called SMART-Band (Figure 2), is used to measure the changing body physiology. The SMART-Band (SMART-BAND by www.bodymonitor.de) was developed by GESIS, the Leibnitz-Institute for Social Science in Mannheim/Germany (Papastefanou 2009).

During the research study, the physiological data is recorded for every second. That is the premise to couple and synchronize the physiological data with GPS- and video camera data. The combination of the different data streams offers new opportunities to understand the complex coherence between the individuals' feelings, emotions, perception and the environments.

This approach was already pursued in several project studies. First test series were done in the emomap-project (Zeile, 2010). Furthermore, the so-called EmBaGIS (Emotional Barrier-GIS)-studies were conducted in the context of urban spatial barriers for handicapped (Bergner et al., 2011). Only recently studies concerning the correlation of stress and noise load and also emotional sensing of urban green areas were carried out (Bergner et al., 2012), as well as another study documenting the perceptual experience of pedestrians participating in one of the demonstrations in Alexandria (Taha, Raslan, and Bergner, 2012).

4.2 Factors affecting pedestrians' perception

To reach an optimum public space usability, a solid guidance is needed that displays the best conditions and designs of the sidewalks, how far sidewalks should be placed from moving traffic, when and what type of buffering or protective barriers are needed and how wide the sidewalk should be. That leads to the need of establishing some measuring factors to assess and plan urban spaces. These factors can be classified into tangible and non-tangible factors.

According to Landis, et al (2001), intangible factors are sidewalk capacity, quality of the walking environment and pedestrian's perception of safety and comfort with respect to motor vehicle traffic. However, the perceived safety or comfort has been a challenging factor to be quantified as a stand-alone performance measure. Contrarily, tangible factors are thought to significantly affect pedestrians' sense of safety or comfort. They include the presence of sidewalks, lateral separation from motor vehicle traffic, barriers and buffers between pedestrians and motor vehicle traffic, motor vehicle volume and composition, vehicle traffic speed, driveway frequency and access volume, among other factors.



Figure 4: Daytime and Nighttime Activities along the Path

4.3 The selected path

El-Geish Promenade, or as Alexandrians call it "El Cornice", is the most famous walked path in Alexandria, either for utilitarian or for recreational purposes. It represents an average of a 4.0 km stretch along the Eastern Harbor (3.87 km on the sea side and 4.30 km on the inner side), from the Citadel on its west end to the Bibliotheca Alexandrina on the east (figure 3).

This path is used by locals to reach the Courthouse-Complex, to access El Mansheya Square and the French Gardens, or to get to the famous Abu-El-Abbas Mosque within the Mosques-Square. Furthermore, this

promenade is used by both locals and foreigners as a major strolling, jogging, recreational and entertainment strip, since it harbors many restaurants, hotels, traditional coffee-houses, shops, as well as public gardens. For the small-budget pedestrians, just sitting by the water-front, watching fishermen in the morning or sipping a cup of tea, eating a corn-cob or a piece of hot sweet potato at night, it provides the needed get-away after work or in the weekend (Figure 4).

While the inner side of the path is almost completely planted with palms or trees, palms can be found on the outer (water-front) side from the beginning of the path as far as section 9, and again towards the end of the path, across the Bibliotheca Alexandrina.

4.4 The event description

The experiment took place on Thursday, November 3rd 2011 at 8:30 am. It started at the west side of the Eastern Harbor (green node) and ended almost 45 minutes later at Bibliotheca Alexandrina at the east side of the Harbor (blue node). The weather was very pleasant that day, with a clear sky and moderate temperature. Two female participants joined the experiment. Each was equipped with one video camera, one GPS tracker, as well as one SMART-Band. Participant A took the outer side of the path (the one closer to the waterfront), while participant B took the inner path (the one adjacent to the buildings).

5 FINDINGS AND ANALYSIS

Participant A showed more stress responses (112 readings) through the 3.87 km stretch along the waterfront (Figure 5) than participant B, who showed only 46 stress points along the 4.3 km walk at the inner side of the path (Figure 7).

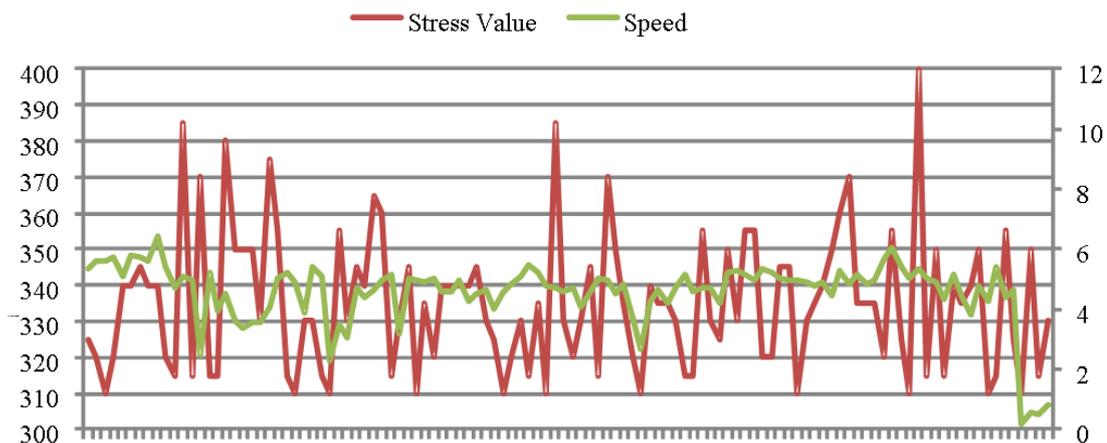


Figure 5: Participant A's Speed and Stress Response by Location

The average pedestrian's speed reaches 4.5 km/hr (Knoblauch, Pietrucha, Nitzburg, 2007). When dismissing extreme values, the speed of participant A varied along the complete path from 7.5 km/hr to 0.04 km/hr (slow speeds were present at the very beginning and at the end of the path), with an average speed of 4.68 km/hr. The average speed recorded at the locations of stress responses is not far from that value. It reached an average of 4.58 km/hr. Extremely slow speed tended to happen at the end of the path, when participant A was first looking for her colleague and then was talking on the phone, stating that she finally reached her target (Figure 6).

Stress responses were spotted when participant A faced pedestrians coming in her opposite direction of travel, when she had to step down or step back on the sidewalk, or when cars or pedestrians blocked her path. Participant's speed did not relate to the altitude of the sensed stress responses at those incidents. Both below-average and above-average speed was spotted at recorded stress points (Figure 5).

The stress points charted by participant B were significantly less in number than those spotted by participant A. However, the same causes triggered the recorded stress responses for both participants. Existing causes were: (1) blocked paths, by cars or by opposite coming pedestrians, (2) stepping down and back on relatively high sidewalks, (3) crossing intersections, especially when they are relatively wide, lack traffic signal lights or have cars coming from more than one direction.

Same as in the case of participant A, Participant B’s speed did not relate to the altitude of stress responses. Both below-average and above-average speeds are spotted at recorded stress points (figure 7).

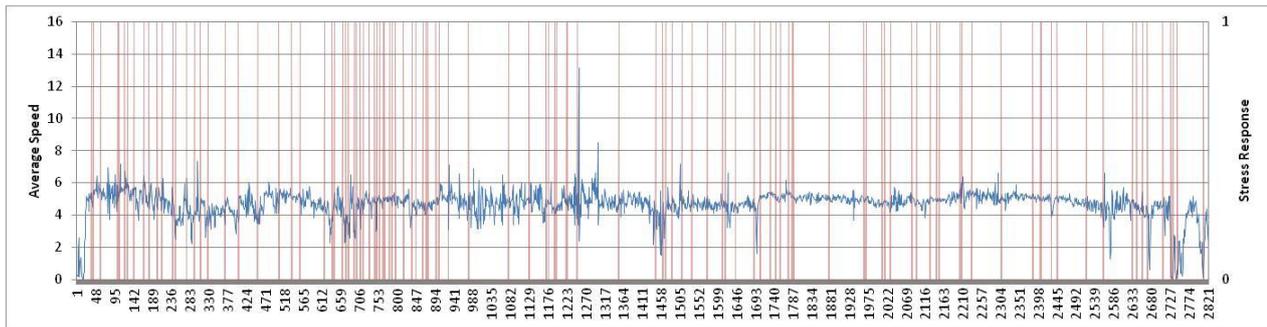


Figure 6: Participant A’s Speed and Stress Response along the Path by Time

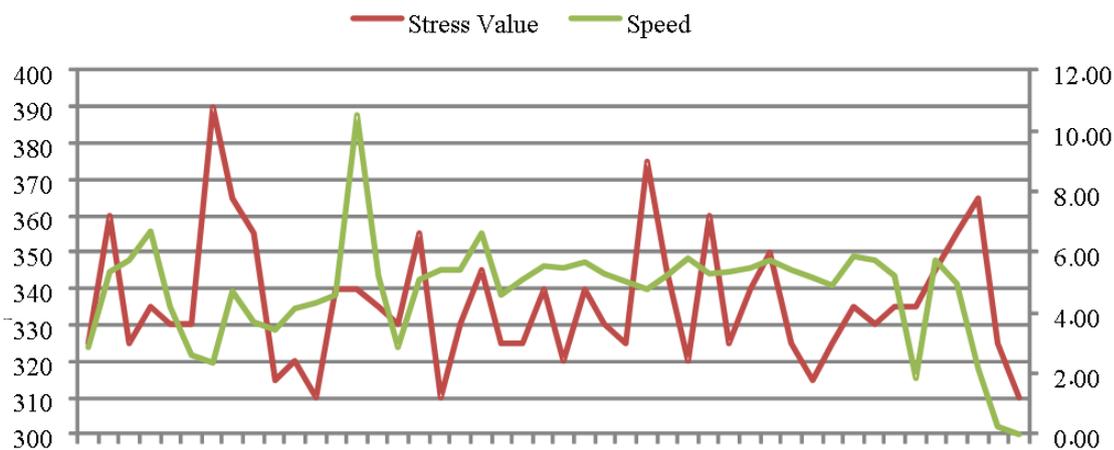


Figure 7: Participant B’s Speed and Stress Response by Location

Participant B showed perplexing speed values along the path (Figure 8). Speed ranged from 0.01 km/h to 15.24 km/hr, with an average of 4.68 km/hr. The exaggerated maximum speed values can be caused by inaccuracies in the GPS tracker. When it loses satellite’s signal, the following GPS data-pair is farther away than the preceding data. However, the average speed along the complete path (4.68 km/hr) is close to the value of the average speed recorded at the locations of stress response points (4.73 km/hr), which in turn is not far from the average pedestrian speed (4.5 km/hr). As participant B was taking the inner side of the path, which had about 40 intersections, speed variations occurred at those intersections. While in some cases participant B had to slow down or even come to complete stop to wait for a traffic signal or crossing cars, in other cases, she had to speed up to cross the intersection. That was because of the lack of traffic signals or speed tables that slow down vehicular movement that crosses pedestrians’ movement.

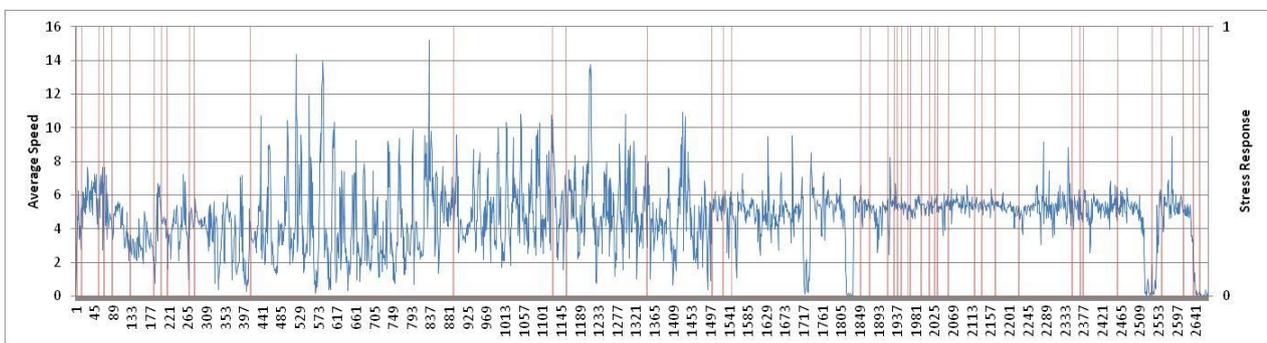


Figure 8: Participant B’s Speed and Stress Response along the Path by Time

Participants A and B showed different intensities of stress responses in different zones of the path. When comparing Figures 6 and 8, representing the location of charted stress responses along the path, it is recognized that both participants showed moderate stress intensity at the start of the path. However, while

proceeding with the walk, participant A showed very high intensity of stress responses between sections 3 and 6 and again between sections 9 and 12. On the other hand, participant B had very few stress responses during that whole phase. Instead she had a relatively dense response rate from sections 12 to 15. Approaching the end of the path, both participants reflected more or less medium density stress response rates, although a higher density was on participant A's side.

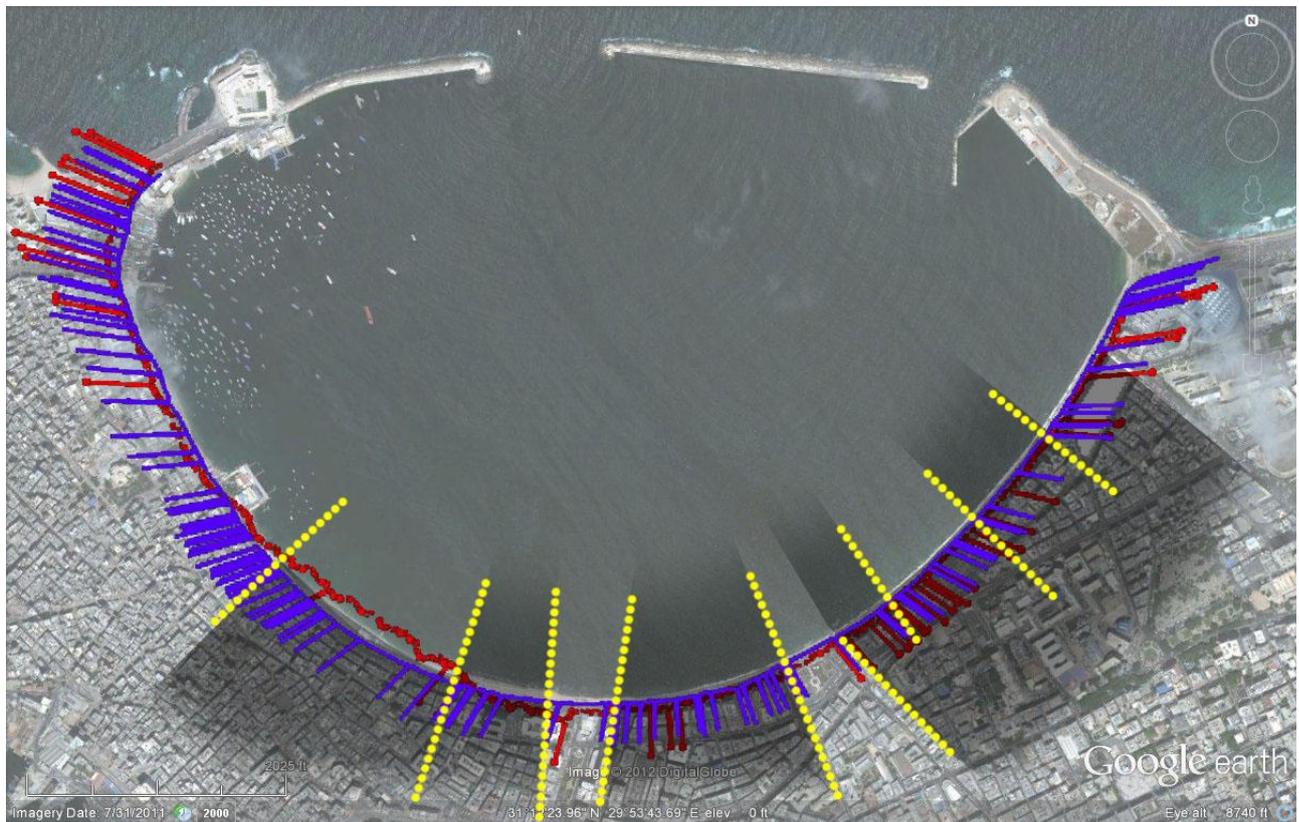


Figure 9: Shaded Zones along the Study Path and Stress Responses from Participant A (blue) and Participant B (red)

Walking in shaded areas or sunny ones did not have any effect on both participants. Figure 9 demonstrates which areas were shaded or sunny on both sides of the path along with stress responses from both participants. During hot summer days, it would have been expected to find dense stress responses in non-shaded areas. However, since the test was taken on a cool November day (where average temperatures range between 19 °C and 22 °C), zones on the path across open spaces, where shade was completely missing, caused no stress at all. At the beginning of the path (for both participants) and towards the end of it (for participant A) shade was missing. However, stress responses were spotted almost with the same density as in shaded areas along the path.

6 DISCUSSION AND RECOMMENDATIONS

Many situations were expected to be stressful out of the comprehension of everyday life, i.e. passing cars. The measurement of physiological indicators shows that in these situations no response was sensed with the SMART-Band.

The intersections at the Unknown-Soldier Monument represent two of the major streets with a high traffic density, where the traffic situation gets often quite chaotic. The first intersection (to the West) is a hub for all sorts of public transportation: taxis, mini-busses and larger busses. While crossing the first intersection, participant A had to take care of mini-busses parked at the intersection, loading and unloading passengers, as well as other vehicles coming from the main street, taking a right-turn (coming from the blind spot of the participant) into the side-street. On the second intersection, participant B had to speed up and dodge vehicles, since there were no means to slow them down by traffic signals or speed tables. However, when participant B was crossing those intersections, no response was sensed (Figure 10).



Figure 10: No Stress Responses were Perceived While Crossing Two Major, High Density Streets

This might be due to several factors. The subject might have been accustomed to those situations, but a foreigner might show some stress if put in the same position. Nevertheless, in the case study some indications which allow raising some hypotheses were observed. There were more stress responses on the sidewalk near the waterfront, than on the sidewalk with buildings on one side and the street on the other. It is assumed that the wider perception of the waterfront participant involves more spatial impressions, which can elicit stress. So the hypothesis is raised that a channeled perception has a more channeled impact on stress reactions in context with the near surroundings. In the study, more influencing factors on the individual perception were observed. Stressful situations were recorded when the participant encounters and perceives other pedestrians or groups. Also the car density and hence the load of noise during the study was higher on the waterfront as on the building side. The many billboards arising attention on both sides of the path were one further influencing factor on perception.

Participant A reflected more stress responses as participant B (112, 46 respectively). This is not only due to the wider perception chances on the waterfront side of the street, but it should also be mentioned that in yet another study, participant A also reflected more responses than participant B while taking the same path. However, while in the previous study stress responses for participant B reached 77% of those of participant A (260, 338 stress responses), in this study they only reached 41%.

These indications show the high complexity of urban open space and its design. In the past it was not possible to objectively measure this complexity in context of human perception. The measurement of unswayed physiological data and thus the individual feelings and emotions in combination with GPS-data offer urban planners new perspectives to understand urban open spaces from the view of its users. Hence, the employment of new technologies to sense space, like the SMART-Band, shows its high potential. But further research with more participants has to be done to get more robust data in case of decision making relying on this data.

7 ACKNOWLEDGEMENT

The authors are grateful to the support of the University of Kaiserslautern for financing the “Laboratory for Monitoring and Spatial Sensing”, including the sensor equipment for this international research project. Also, the authors would like to express their gratitude to the German Research Foundation (DFG – Deutsche Forschungsgemeinschaft) for supporting the project “Development of methods for spatial planning with GeoWeb and Mobile Computing (Städtebauliche Methodenentwicklung mit GeoWeb und Mobile Computing)”.

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