# Identification of Stress Situations in Urban Space

When biosensors capture emotions

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***Abstract*—This study raises the question of stress situations in public space. Interested in the well-being of city users while evolving in town, we performed an experimentation based on a multidisciplinary methodology that combines qualitative and quantitative data resulted from commented walks in urban areas at city-center of Tunis. Stress level physiological measurements, called Electro Dermal Activity (EDA), are generated while crossing these areas and analysis of the soundscape were conducted. The target of this paper is to check the links between urban sound phenomenon, the stress of participants and architectural and urban characteristics of space. Our research aims to reduce those stress situations and to propose adequate urban configuration to make the city accessible to everybody.**

***Keywords-stress situations; urban space; Electro Dermal Activity ; Q sensor; emotions.***

## I. INTRODUCTION

Using urban space often calls for physical and perceptive skills [1]. Users experience the city by walking, driving, using public transportation, etc., and all those actions cannot be taken correctly if we don't consider the urban accessibility for all city users. Many studies revealed that incompatibility between the urban and architectural environment and the physical capacities of city user can lead to stress situation and dissuade to attend the city [2]. Urbanites and architects work together on challenging situations of stress in urban space and to design a city in line with the well-being of her users.

This multidisciplinary research invokes the human psycho-physiology dimension as a pertinent indicator of stress levels in urban space. Using knowledge ranging from urban studies [3] to information and communications technologies, this work aims to draw attention to original application of the sensor techniques in city studies.

Thus, to highlight those stress situations, we need to characterize them by analyzing the arousal levels via psychophysiological measures called EDA [4]. When an emotional arousal occurs, the brain receives signals translated by electrical changes at the skin surface.

Those psychophysiological signals are characterized by the succession of Skin Conductance Responses (SCR) [5] as illustrated in Figure 1, which represent the relationship between stress and EDA signal. Those skin conductance data represent events-related alertness, characterized through three components [6]:

-The amplitude: after stimulation, the signal resistance goes down to a minimum point; then it backs to its initial value. The amplitude of the SCR is measured by the difference between the maximum point and the minimum point of the signal.

- The duration d1: it is the time interval between the maximum point and the minimum point of the SCR

- The duration d2: it is the time interval between the point which marks the peak of the SCR and the point where the signal returns to 50% of the amplitude of the same reply.

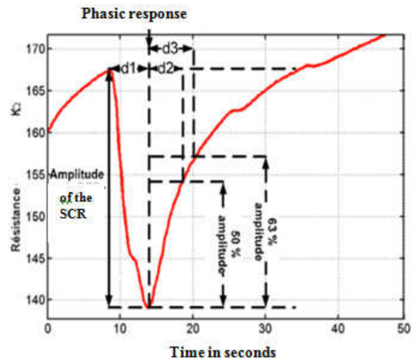


Figure 1. EDA variation and ocuurence of a SCR.

The SCR measures application covers a multitude of fields, such as health research, as well as urbanism discipline where they can be objective indicators of measuring arousal level when walking in the city [7]. Then, situations of stress can be identified and urban space accessibility and safety can be enhanced.

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The remainder of the paper is organized as follows: Section 2 details the experimental protocol and the data collection process. Section 3 presents the results of an EDA and sound sources correlation. We discuss in Section 4 the relationship between stress situations and urban configurations. Section 5 concludes with a summary and an outline for few perspectives to this study.

## II. EXPERIMENTAL PROTOCOL

This study is based on a multidisciplinary experimental protocol of three components:
- Spatial analysis: it's an urban graphic survey that shows urban crossroads (plans, spatial configurations, etc.) [8].
- Analysis of the physical signal: This part is divided into three parts: sound level measurements (acoustic metrology), audio records and analysis of spectral compositions.
- The perception of sound phenomena which is composed of two phases:

  - First, the commented walk method [9], which requests from the participant three simultaneous activities: walking, perceiving and describing what she/he heard. The aim of these walks was to obtain a full record of the multi sensorial perception in movement and the audio perception in particular. During each walk, we paid particular attention to behavioral indicators to help us analyze the relation between each subject and their surroundings [10][14].
  - Secondly, the capture of user's arousal (emotion) which is based on the capture of the physiological data during the commented walks by the biosensor (Q-Sensor). Emotional arousal is a form of EDA that increases during states of stress, anxiety or excitement and decreases during states of boredom, relaxation or indifference. Additionally, the sensor measured the participants' temperature and speed but also tracked their stress level [11][12].

### A. Material

To realize this experimental protocol, we used these following devices:
- Q-sensor, which is a hand wear device; this is a biosensor of EDA (sampling frequency 32 Hz). It measures via the skin conductance the arousals, the temperature and the acceleration of the user for a 24-hour. Those data can be visualized thanks to software called "Q" (developed by the startup Affectiva from the Affective Computing Group of MIT Media Lab) [13]. It produces curves representing the EDA activity. Awareness' moments are detected through specific peaks.

(A) (B)

Figure 2. The Q-Sensor.

- A digital voice recorder (sampling frequency 44,1 KHz). It is used to record the different sound sources along the walk. The dynamic frequency (spectrum) can be read by software called "audacity"
- A sonometer: A sound level meter that measures the noise levels. The unit used is the decibel, dB (A).

### B. Field of the study

Our choice was fixed on the downtown of Tunis. This field is considered as a part of city development and urban growth articulation point between the south and the north of the capital. Our study focuses on two paths.

The first one, represented in red in the Figure 1, begins by the intersection between the *Yugoslavie* street and *Greece* street, then passes near the subway station « *Place Barcelone* » and ends at the intersection of the united Nations avenue, *Yougoslavie* street and *Farés El Khoury* street.

The second path is represented in green in Figure 1. It is located on the main avenue of the down town of Tunis, *Habib BOURGIBA*. Then, it passes by the most important crossroad "14 January square".

These walks include a variety of urban situations: a subway crossing, several potential crossroads, official establishments, bars and pedestrian walks. It is also known the trade activities on the ground floors and habitat and offices on the other floors building with three to ten floors).

It is divided into different sectors (zones), fig, according to variety of functions: in the first one, we note the diversity of the activities (mall, coffee shops, passage of the subway, etc.); the second zone is a habitation zone and small trades; then, the third one is a mechanic works' sector with buildings of just a ground floor or high ground floor; with the abundance of pedestrian walks. Finally, the forth sector is known by the importance of the traffic along the day and the rarity of the pedestrian walks and the trade markets. This diversity affects the quality of the soundscape.

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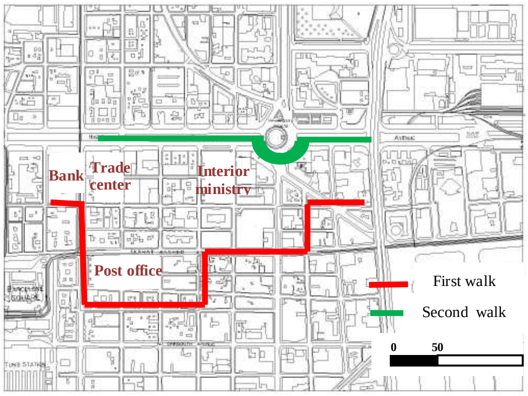


Figure 3. The field of the study.

## C. *Population*

Our target population was about thirteen persons. In this paper, we will present the results of four cases: two men and two women, aged between 20 and 80 years. The experiments were made between 2010 and 2011. Each subject performed a commented walk in the itineraries previously chosen. Participants must wear the sensor just five minutes before the beginning of each walk (a necessary time for the sensor adaptation) [16]. During the experiment, we asked the subject to describe his feelings toward the ambiance and specially the sonic ambience. Here, the investigator's intervention should be minimal (just to remind the set point to the respondent) in order to not influence the participant.

# III. RESULTS

To identify the different stress sound situation [15][17][18], we have to correlate the different levels: the audio analysis, the physiologic data and the speech of the respondent.

In this section, we will present the EDA data collected from the two experiences (two walks).

## A. *The first experience*

For the first experience, illustrated by Figure 4 and Figure 5, we will present the EDA curves of a man of 39 years old and a woman of 45 years old in the first path (represented in red in Figure 3). We obtain:

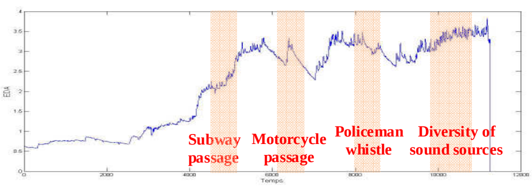


Figure 4. First experience: The EDA curve of the first subject.

We identify, in Figure 4, different sound stress situations (as explained in Figure 1). Some are related to particular sound sources (policeman whistle, passage of a motorcycle or the subway). We found that on the comments of the respondent "*The subway arrives. (...) And it bothers me*" or "*(…) I don't like **motorcycles** that speed after the turn*"or "*oh! The policeman whistle's is very disturbing!*" In other situations, we note also the multiplicity of the sound sources. "*The **noise becomes more important** than the other street. Especially here with this intersection, there is every kind of noise. I don't feel good anymore.*"

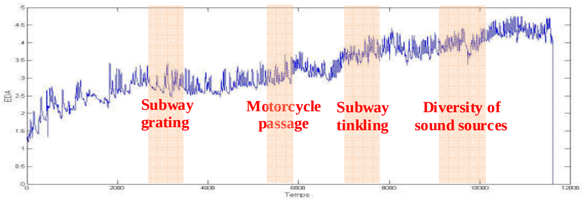


Figure 5. First experience: The EDA curve of the second subject.

In Figure 5, we note also two types of sound stress situations: due to particular sound sources and due to the diversity of the sources. This was confirmed by the comments of the users. "My *god! What's this sound? Oh! It's the subway grating*" and also "*But here it starts to fuss. (…) The noise increases, we approach the source of the noise, oh there are many here: Cars, pedestrians, motorcycles, hawkers…so, necessarily the tension rises*"

## B. *The second experience*

For this experience, we will present, in Figure 6 and Figure 7 two EDA curves corresponding to two cases of a man of 83 years old and a woman of 63 years old in the second path (represented in green on Figure 3).

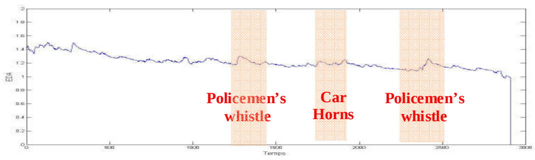


Figure 6. Second experience: The EDA curve of the first subject.

The sound stress situations detected in Figure 6 are linked mainly to the policeman whistle and the car horns even if the subject does not express clearly that she heard them. Due to age, elderly suffer from hearing loss and they cannot identify some sounds. This was confirmed by the EAD where we identified stressfull sound events but the participant expressed them in her comments leaning on the visual parameter: "*I hate this place, I can't deal with the cars…they don't respect pedestrian…Look! He is speeding with his car (…) There is a policeman, good job! I don't come here very often since I'm afraid from the traffic jam, I have difficulties to hear, and it's dangerous for me to go out of my home…*"

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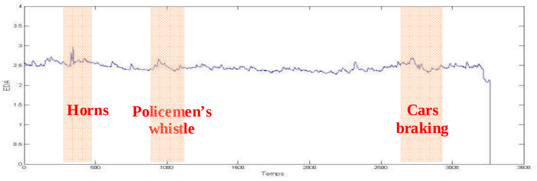


Figure 7. Second experience: The EDA curve of the second subject.

In Figure 7, we find the same disturbing sound sources, which are mainly the policeman whistle and the car brakes. The EDA of this subject reflect his stressful state by the succession of the SCR and the disturbed curve. This subject identified clearly the whistle's sound and after examining his clinical case, we discovered that he's wearing an internal audio prosthesis. These findings are confirmed by the verbal data: *"it's a crowded place! …I don't feel secure, many cars and I can't even distinguish the traffic light to cross the road…Oh, and I'm listening to a whistle!!! A policeman, yes it's good (…) I hope he'll help me to cross, I'm feared…I have a headache"*.

## IV. Discussion

We will try in this section to correlate the results above by the audio data; so, we present in this paper just one case. We confront the EDA signal with the spectrum of audio signal recorded among the walk.

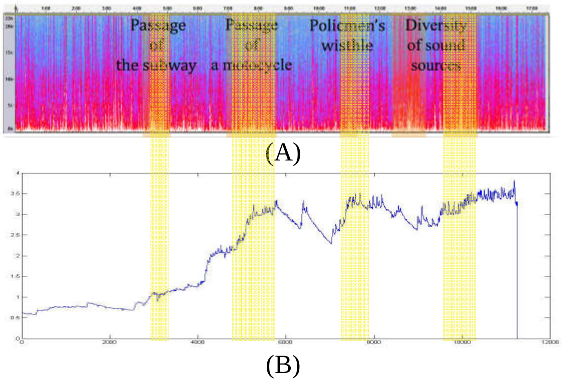


Figure 8. Correlation between the spectrum of the audio signal(A) and the EDA curve (B), case1.

The analysis of spectrum frequent of the audio signal highlights the physical characteristics of the urban space. Our setting is composed by a diversity of sound sources which compose an urban background sound made of high frequency of 10 kHz. We have note, also, in the last section that the stress feeling in the urban space, for the four cases presented in this paper, is linked to particular sound sources, situated on high and medium frequencies, such as the whistle of the policeman with 4 kHz, horns of the cars, grating and tinkling of the subway composed by signals between 8 kHz and 12 kHz and also, acceleration and braking of vehicles (cars, buses, motorcycles, etc.), which are high frequency signals by 12kHz.

By characterizing the complexity of the urban soundscape, we can conclude that the nature of the sounds and their frequency content are one of the causes of stress and discomfort feelings and emotions of the urban space users.

However, those results can be more discussed if we analyze with more accuracy EDA curves. In fact, the link between audio signal, EDA data and the commented walks cannot be highlighted if we don't consider the specificity of the urban configuration, the scene of the experience [19].

## V. Conclusion

We presented in this paper an original approach of detecting arousal states via biosensors in city studies. In fact, according to the interest given to the question of pedestrian well-being and safety and how they experience the city, we developed a strategy to identify stress situations in urban space.

Through this multidisciplinary research, we adopted an exploratory approach to characterize the sound signal in order to detect the stressful information contained in complex soundscapes. By combining tools that qualify and quantify the informational content of the sound scene in the city, we achieved our task taking into consideration not only the audio parameter, but all senses, as a part of the multisensory experience of pedestrians in the city.

We were able to rich our goal thanks to the collaboration between many disciplines: architecture, psychophysiology, signal processing, urban design, etc. We identified stress situation by linking the sound event, the human perception and the urban configuration. It is important for architect to identify disabled spaces in the city that may cause problems for pedestrian, especially ones with disabilities, in order to correct them and to propose new urban design that may help to make the city safe for all users [20].

Among the perspectives of this work, we tend, using this protocol, to improve the graphical stage of any project realization with sound mappings for specific city users thereby improving the chances of their safety level during walking or crossing roads for equal accessibility of urban spaces by all users.

The affective dimension of the study represents a new response that shows potential on the perceptual dimension of a given category of city users [21]. The aptitude to personalize a given soundscape design while considering age, gender, physical and mental capacities of a specified class of population is an important step forward in a society that aspires for stress control. In that regard, a personalized study would be more useful instead of a group one. Such objective would be line with a global well-being.

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