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WALK SAFE PROJECT: PERCEIVED SAFETY RELATED TO SOUNDSCAPE OF THE URBAN SPACE AND CONDITIONS OF ARTIFICIAL LIGHTING

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ABSTRACT

Particularly in this historical period, urban safety and its perception are rarely the same. Walk Safe Project aims to analyze the perception of urban safety in relation to soundscape, lightscape and urban quality, with the purpose to develop an evaluation protocol based on objective and subjective investigations. This was applied to four critical areas of the City of Turin (Italy). Subjective data was obtained, in night hours, with 124 surveys from October to December 2018. Acoustic measurements were performed using the calibrated binaural recording system Siemens SCADAS-XS and the values of A-weighted equivalent sound pressure level and some psychoacoustic metrics were extracted. Simultaneously HDR photos were taken and converted into luminance images, in order to document the lightscape. All the data was processed together through statistical analysis and perceived parameters were extracted. The results show that environmental characteristic like soundscape, lightscape and urban quality have a fundamental role on perceived unsafety. Perceived unsafety is positively related to the pleasantness of technological soundscape and negatively to the perception of anthropic soundscape. Sharpness Aures and Tonality are the objective parameters that relate with the anthropic one. Further, perceived unsafety is negatively correlated to visual interest and visual lightness and to urban quality.

1. INTRODUCTION

Starting from the Lynch works [1], the study of perception is based on people interaction with the environment through visual, auditory and other sensory receptors [2]. Particularly in this recent historical period, safety and its perception are rarely the same: this depends on the interaction of mental processes with physical, mechanical and perceptive implications [3, 4]. When these factors are not congruent with reality they change into "perceptive dissociation" [3], also due to the persuasive effect of the media that centralize public opinion on crimes [5], without a real statistical response [6]. Nowadays dissociative perception is the basis of perceptual processes, because the data collected from the environment are not sufficient to respond to perceptual aspects. The perception of safety varies according to gender, ages and education level, fear of criminals [7] and some environmental characteristics, such as soundscape, lightscape [8, 9, 10], urban decay [11], and social presence [10]. This dissociation also causes the loss of trust in the authorities and in the increase in private security systems [7].

The livingscape is the set of environmental characteristics that affect the quality of life, it is therefore connected to the dynamics of safety and it is necessary to investigate the aspects linked to the structure of the physical city and the perceptions of the citizens [12].

In this context, Walk Safe Project aims to analyze the perception of safety in relation to the characteristics of soundscape, lightscape and urban decay environment. This is possible with the development of an evaluation protocol based on objective and subjective in-field investigations. The application of this protocol to some study areas in the City of Turin can support urban spaces planning decision-making processes, in particular the aspects of sound and lighting environments.

2. METHOD

This perceived safety evaluation protocol was applied to four areas of the City of Turin, determined in collaboration with the Municipal Police Corps of the City of Turin. This choice was based on the characteristics of the place, good or bad conditions of light, sound and urban decay as shown in Figure 1.

Figure 1. a) Campus Luigi Einaudi, b) Parco Dora, c) Passerella Olimpica, d) Largo Saluzzo.

It was decided to apply the methodology of sound-light walk: for each area a walk with five significative stations, as shown in Figure 2, were identified for the objective and subjective data collection. The perceptive data was

obtained by a structured survey with twenty-one questions. The filling in time was six-minutes.

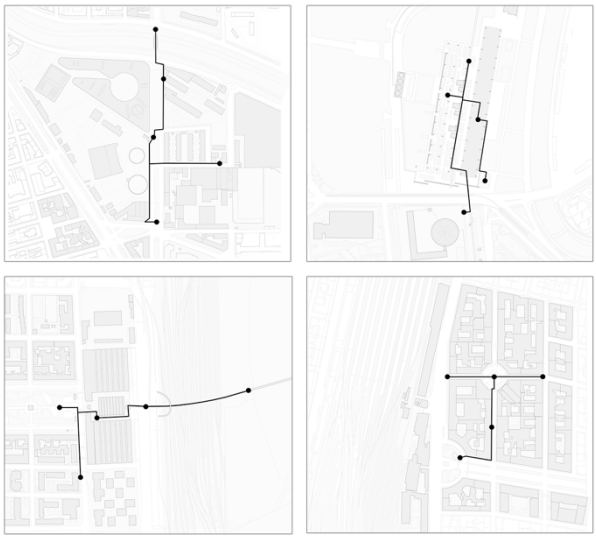

Figure 2. Sound-light walk of a) Campus Luigi Einaudi, b) Parco Dora, c) Passerella Olimpica, d) Largo Saluzzo.

The questionnaire was subdivided into five sections aiming to investigate different aspects of the four areas: 1) perceived safety [13], 2) urban decay, 3) lightscape [14], 4) soundscape [15], 5) wellbeing [16]. Personal information was also collected at the beginning of the questionnaire. It was administered to 124 persons from October to December 2018, three days a week (Mondays, Thursdays and Saturdays), four weeks (one for each case study) from 8.00 to 11:30 p.m. (half an hours for each station). With the purpose to investigate the soundscape conditions during the survey, acoustic measurements (5 minutes for each station) were performed, as shown in Figure 3, using a binaural recording system composed of a portable audio recorder SCADAS XS with GPS receiver, connected to the SCADAS XS binaural headset with recording microphones.

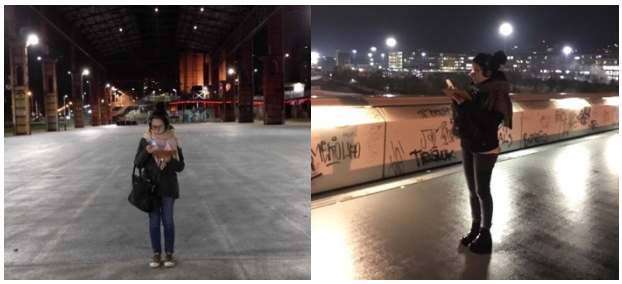

Figure 3. Sound measurements using a binaural recording system.

This system was controlled via Android app Siemens Testlab Scope 7. The audio files collected were analyzed using the Simcenter LMS Testlab (Siemens PLM Software, v.17) and from the measurements the overall A-weighted equivalent sound levels and selected Psychoacoustic Metrics were extracted [17]. In adherence with the soundscape characteristics, the following metrics were al last considered: Fluctuation Strength, Roughness, Sharpness Aures, Sharpness DIN45692, Tonality and Tonality DIN45681. Simultaneously a Canon EOS 650D with 17-50mm lens to shoot HDR photos in the observer direction was applied, in order to document the environmental lighting condition. The photos were subsequently converted into luminance images via LMK labsoft 4 v17.10.10. The objective and subjective data collected were processed through statistical analyzes.

2.1 Statistical Analysis

Statistical analysis was carried out with SPSS Statistical Package for Social Sciences (IBM Statistic20, IBM, Armonk, NY, USA). The analyzes were carried out with:

- Principal Component Analysis (PCA) to obtain latent factors;
- Linear regression analysis in order to estimate the conditional expected value of a dependent variable given the value an independent variable;
- Bivariate correlation analysis, with Pearson linear correlation coefficient, in order to estimate the correlations between two or more distinct variables.

3. RESULTS

From the PCA with Varimax rotation of the on-site survey, some latent factors on unsafety aspects, lightscape and soundscape were obtained. The first analysis reduced the questions related to the perceived safety into three components, as shown in Table 1: Perceived Unsafety (PuS), Perceived Social Presence (PSP) and Perceived Urban Quality (PUQ), which explained 63.5% of the cumulative variance. PuS is the main factor and its main related aspects are related to the unsafety feeling. Only medium-high values of the component's loadings, which represents the correlation between the variable and the component, are highlighted ($\geq |0.5|$). The same analysis was carried out on the soundscape questions and three factors were obtained, as shown in Table 2, that explain 58.6% of the cumulative variance. Particularly, Pleasantness of Technological Soundscape (PTS), Perception of Anthropic Soundscape (PAS) and Perception of Natural Soundscape (PNS) were found. The same analysis was carried out on the questions related to the light environment, as shown in Table 3, that explain 54.0% of the cumulative variance: Visual Lightness (VL), Visual Interest (VI) and Visual Chromaticism (VC) are the three explaining factors. Table 4 shows the correlations between PuS and the perceived factors of the light environment, acoustic environment and the factors related to the perception of urban quality and social presence. The significant related factors ($p<0.1$) are PSP, PAS, VL, and VI, thus showing the importance of light and acoustic conditions in the perception of urban safety as well as the importance of the perceived social presence. The perception of unsafety is negatively related to perception of social presence (PSP), of anthropic soundscape (PAS), Visual Lightness (VL) and Visual Interest (VI) [18]. This

means that urban safety increases with social presence, presence of anthropic sound, visual interest and visual lightness of the urban site.

Items	PuS	PSP	PUQ
To what extent do you agree or disagree with the following sentences? (from *strongly disagree* to *strongly agree*)			
I feel worried	**.783**	-.166	-.163
I feel restless	**.779**	-.160	-.239
I feel comfortable	**-.678**	.288	.354
I feel safe	**-.731**	.102	.334
I feel alone	.378	**-.612**	.076
I would walk alone along this place	**-.759**	-.007	.196
I would extend my route to avoid walking in this place	**.809**	.079	-.006
I am feeling uncomfortable along this route	**.804**	-.208	-.193
I would quickly cross this place to get away from here	**.814**	-.257	-.085
I have an unpleasant feeling in this place	**.770**	-.290	-.153
This place is attractive	-.447	**.565**	.264
This place seems full of life	-.142	**.780**	.266
This place looks like a cozy environment	-.126	**.816**	.185
I feel like there is someone else in this place	.090	**.581**	.307
This place seems to be designed for users	-.215	.225	**.520**
How do you describe the elements of the urban context that surround you? (from *very bad* to *very good*)			
Maintenance of buildings (decay conditions)	-.180	.234	**.617**
Maintenance of public spaces	-.194	.124	**.864**
Cleaning of public space	-.180	.127	**.806**

Table 1. PCA of questions related to PuS: component matrix for three factors. Only medium-high values of the component's loadings are highlighted (≥ |0.5|).

Items	PTS	PAS	PNS
To what extent do you presently hear the following three types of sounds? (from *I don't hear* to *Dominates completely*)			
Traffic or technological sound	**-.467**	-.102	-.370
Sound from human beings	.042	**.686**	.057
Natural sound	.024	.195	**.730**
To what extent do you agree or disagree with the following sentences about soundscape characteristics? (from *strongly disagree* to *strongly agree*)			
Pleasant	**.624**	.310	.224
Annoying	**-.633**	.107	-.342
Eventful	-.214	**.757**	-.168
Uneventful	.158	**-.660**	.238
Calm	.183	-.354	**.747**
Chaotic	-.277	.266	**-.681**
Vibrant	.289	**.730**	.182
Monotonous	-.198	**-.699**	.085
Overall, how do you describe the present sound environment? (from *very bad* to *very good*)			
	.874	.037	.030
Overall, how loud is it here? (from *not a lot loud* to *extremely loud*)			
	-.588	.406	-.203
To what extent the sound environment is adequate for the use you make of this place? (from *not adequate* to *extremely adequate*)			
	.821	.042	-.023

Table 2. PCA of soundscape questions: component matrix for three factors. Only medium-high values of the component's loadings are highlighted (≥ |0.5|).

Items	VL	VI	VC
In lighting environmental setting, how much do you see the light source that surround you? (from *I don't see* to *Dominates completely*)			
Street lighting	**.523**	.105	.162
Architectural lighting	**.499**	.162	-.252
Indoor lighting	**.384**	.175	-.015
To what extent do you agree or disagree with the following sentences about lighting environmental characteristics? (from *strongly disagree* to *strongly agree*)			
Pleasant	.387	**.671**	-.176
Chaotic	.110	**-.615**	.281
Stimulant	.191	**.672**	-.103
Gloomy	**-.643**	-.248	.403
Warm	.270	.349	**-.683**
Cold	-.039	-.145	**.797**
Glaring	**.581**	-.294	.028
Monotonous	-.025	-.138	**.625**
Relaxant	.208	**.807**	.106
Uniform	.187	**.735**	.040
In general, how do you describe the lighting environmental settings? (from *very bad* to *very good*)			
	.652	.498	-.134
In general, how do you seem bright the lighting environmental settings? (from *not bright* to *extremely bright*)			
	.826	.101	-.209
To what extent the light environmental setting is adequate for the use you make of this place? (from *not adequate* to *extremely adequate*)			
	.769	.329	-.087

Table 3. PCA of lightscape questions: component matrix for three factors. Only medium-high values of the component's loadings are highlighted (≥ |0.5|).

	β	p.value
R .672, R^2 .451, ANOVA p = .000		
PSP	-.239	**.025**
PUQ	-.122	.164
PTS	.091	.295
PAS	-.155	**.086**
PNS	-.016	.839
VL	-.293	**.001**
VI	-.395	**.000**
VC	.122	.152
wellbeing	-.108	.165

Table 4. linear regression data on the perceived factors of social presence, urban quality, sound, light and wellbeing with perceived unsafety as dependent variable.

On the basis of the results obtained a statistical model of the PuS was developed, as shown in Eqn. (1):

$$PuS = 6.604 \times 10^{(-17)} + (-0.239)\ PSP + \quad (1)$$
$$(-0.155)\ PAS + (-0.293)\ VL + (-0.395)\ VI$$

Due to the low value of the constant, it could be possible overlooked it. Further, the objective values of the sound characteristics measured in-field were investigated. Table 5 shows the correlation between subjective and objective data related to soundscape. PTS is positively correlated with Tonality DIN45681, PAS is positively correlated with LA_{eq}, Fluctuation Strength, Roughness, both the Sharpness and Tonality, while PNS is negatively correlated with both Sharpness and Tonality DIN45681.

Objective parameters	Pearson coefficient and two tailed p-value	PTS	PAS	PNS
LA_{eq}	pearson	-.001	**.388**	-.135
	sig.2tailed	.989	**.000**	.134
Fluctuation Strength	pearson	-.054	**.411**	-.028
	sig.2tailed	.551	**.000**	.761
Roughness	pearson	-.026	**.328**	.022
	sig.2tailed	.777	**.000**	.811
Sharpness Aures	pearson	.026	**.526**	**-.209**
	sig.2tailed	.775	**.000**	**.020**
Sharpness DIN	pearson	-.098	**.333**	**-.274**
	sig.2tailed	.277	**.000**	**.002**
Tonality	pearson	-.013	**.272**	.095
	sig.2tailed	.883	**.002**	.293
Tonality DIN	pearson	**.272**	-.055	**-.367**
	sig.2tailed	**.002**	.545	**.000**

Table 5. Correlations between objective and subjective data related to soundscape.

4. CONCLUSIONS

From the statistical analysis of the data collected through the questionnaire, latent factors were identified on the items of safety, lighting and sound environment, which can be identified as the main perception aspects of people who live the city in the evening in critical areas of the City of Turin (Italy).

The results support the hypothesis that the perception of safety depends on numerous factors including environmental characteristics such as soundscape and lightscape.

People feel unsafe when Visual Lightness and Visual Interest, the perception of anthropic soundscape and of social presence are lower. Anthropic soundscape is an element with a double value: it can lead to noise problems, such as nightlife, on the other hand it can increase the feeling of safety of people. So, for this element it is important to find the right balance, such as a not excessive social presence. Urban planning is therefore essential to find this balance of social presence and consequently of anthropic soundscape.

All these variables play a fundamental role in a conscious design process, which is careful to the theme of safety and of human-centric. The urban planning process that consider the structure of analysis of this research expresses the desire to want to change the paradigm behind the design dynamics, that often respond to purely technical parameters like pedestrian path dispersion and horizontal average illuminance for Visual Lightness or Tonality DIN for Pleasantness of Technological Soundscape. Exactly as it happens with human centric design, a properly designed urban reality has not only implications on the ability to perform an activity properly but also on perception of individual of environmental but also on individual perception of environmental. Furthermore, knowing the technical characteristics of the area and the context in which it is inserted will allow to predict a general perceived safety and the consequent probability of use of the space.

Considering the results achieved with this work, the research intends to broaden the investigations to include other livingscape quantities into the model, such as air quality and thermal quality, which could be also factors of influence.

Other further investigations of this research will concern the characteristics of the interviewee, such as the evaluation of the influence of different type of subjects of the real estate market and of the number and type of complaints in the areas analyzed on the perception of safety. The research has also the future aspiration of being able to expand the study to other neighborhoods and urban contexts.

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