Noise Mapp. 2021; 8:138–161 DE GRUYTER

Research Article

Jerónimo Vida Manzano*, José Antonio Almagro Pastor, and Rafael García Quesada

The importance of changing urban scenery in the assessment of citizens' soundscape perception. On the need for different time-related points of view

https://doi.org/10.1515/noise-2021-0011
Received Aug 21, 2020; accepted Mar 01, 2021

Abstract: The city of Granada is experimenting a big urban transformation, attending national and international commitments on clean air, energy efficiency and savings linked to greenhouse gases reduction strategies and sustainable development action plans. This situation constitutes a good scenario for new noise control approaches that take into account the sound variable and citizens empowering in urban design, such as the soundscape assessment of urban territory. In this way, soundscape tools have been used in Granada as a complementary method for environmental noise characterisation where traditional noise control techniques are difficult to be carried out or give limited results. After 2016 strategic noise map and in the preparation of the new noise action plan, the city came across a great acoustic challenge in a new area located outskirts characterised by growing urbanisation, still under development, the greatest legal protection because of sensitive teaching and hospital buildings and the greatest noise exposure from nearby ringway supporting heavy traffic flow. As quiet urban areas are not characterised by the absence of noise but for the presence of the right noise, this research intended to provide the local administration with results and proposals to transform this conflict area in a pleasant or quiet urban place. Main results came from important and significative differences in morning and evening characterisation, as great differences appear in soundscape assessment over the day and along the soundwalk path, indicating the importance of time and local issues to adequately characterised citizens perception to be considered by administration in the development of strategies and effective noise control actions.

Keywords: noise, environment, perception, soundscape

1 Introduction

Environmental urban noise control and management by the local administration are usually and traditionally accomplished through strategic noise maps (SNM) and local noise action plans (NAP) development. Under this legal and technical approach, citizens' participation, though regulated, promoted and driven by municipal official entities such as Local Agenda 21, has never been anything more than testimonial and quite a minority. In this context, noise control in urban environments rarely includes the way noise is perceived and understood by the individuals or by society.

The city of Granada has a long tradition and experience managing local noise issues. The local administration has always counted on the University of Granada for help and expert assessment on environmental noise management and control through harmonised methods as demanded by law. The collaboration between Granada City Council and the University of Granada has usually led to positive bidirectional synergies enriching both organisms, being Granada 2008 SNM [1], subsequent 2013 NAP [2] and latest 2016 SNM [3] great examples of this collaboration and signs of concern and compromise of the city of Granada with environmental noise management and control.

In this context, Granada is currently undergoing a major urban transformation within Smart City and sustainable development principles to face urban challenges arising from international local commitments adopted in 2009 as a signatory city to the Covenant of Mayors and renewed in 2016 as a signatory city to the Covenant of Mayors for Climate and Energy in Europe [4]. By assuming these commitments, cities and towns take climate and energy action to secure a better future for their citizens focusing on reducing air contaminants (including noise) and greenhouse gases (GHG) emissions and increasing energy savings and effi-

***Corresponding Author: Jerónimo Vida Manzano:** Applied Physics Department, Faculty of Sciences, University of Granada, 18071 – Granada, Spain; Email: jvida@ugr.es
José Antonio Almagro Pastor: Scientific Instrumentation Center, CITIC, University of Granada, 18071 – Granada, Spain
Rafael Garcıa Quesada: Building Construction Department, School of Architecture, University of Granada, 18071 – Granada, Spain

ciency by boosting renewable energy sources. New trends in mobility and transport systems, revised public use of urban spaces or citizens empowering to say some, are different elements of sustainable development that have to be revised, reinforced and integrated for a better quality of life in Granada. If we focus in noise and air issues, sharing emissions sources and demanding integral and integrated solutions, the city should start new approaches to manage and control air contamination problems, linked to particles and nitrogen dioxide mainly emitted by home heating boilers and diesel vehicles, and urban environmental noise from road traffic.

Legal regulations in Spain and Europe include acoustic specifications and requirements for urban areas to be classified as "quiet areas", a type of urban territory highly valued by citizens as indicated by the importance given to the "absence of noise" question in social surveys carried out in Granada for the assessment of community response to environmental noise [5]. But even though this may seem a mere questions of noise levels standards, transforming urban areas into quiet areas is not just a matter of reducing decibels as previous studies in Granada [2, 3, 5] and acoustic environment perception research have shown [6–9]. According to these, the local administration will have it difficult to satisfy sustainability commitments just by putting down urban noise levels, not even using technology in a sensorised town under the Smart City concept, unless the most important sensor, the human sensor, is given a relevant role in the development of urban design, strategies and action plans.

The acoustic environment can be transformed into a valuable urban resource if adequate sound levels rather than low levels are promoted, a task that focuses on sounds people want or prefer [10]. As stated by EEA [11], the term "quiet" may accidentally lead to the assumption that a quiet area is an area with very low noise or even no noise. But when talking about the need for quiet areas and quietness we are referring to urban areas understood as pleasant, but not necessarily silent, by citizens in context [12]. The soundscape approach in urban noise research has already given some answers to main questions concerning the way citizens opinion should be taken into consideration [8, 13]. At the same time, other questions arise as complex relationships between soundscape and public space usage are analysed [14].

Even though soundscape is not a new concept connecting environmental noise and urban planning research, with valid references as early as 1967 [15], the importance of human perception with an emphasis in the context in which the evaluation takes place is taken into consideration by the International Organization for Standardization when defining soundscape as the "acoustic environment as perceived or experienced and/or understood by a person or people, in context" [12] ISO also provides standard requirements and supporting information on data collection and reporting for soundscape studies [16] and guidance on how to analyse data collected [17].

The assessment of the urban acoustic environment taking into consideration people experiences, perceptions or interpretations in context, is something that had never been done before within the local noise management system in the city of Granada. The prevention, management and control of noise issues employing standardized methods have a long tradition in Granada, where high concern has always been expressed by citizens and a high degree of commitment has always been proved by local administration too. Local Agenda 21 in Granada has traditionally encouraged citizens' participation in general sustainable development matters [18]. After more than 10 years of strategic noise maps (SNM) and noise action planning (NAP) according to END [19], new urban areas experiencing great transformations in a new scenario chaired by stricter air quality standards, low gases emissions or energy efficiency criteria, suggested that it was time for the soundscape approach in the city [20].

In this work we focus on the differences found in the objective perception of urban sound quality with time and the associated changing environmental situation in the city of Granada in soundscape characterisation of complex noise affected urban territory under development.

2 Methods

2.1 Case study area

The study area is a new urban area located outskirts characterised by recent growing urbanisation. This area is delimited to the south by surrounded ringway, as shown in Figure 1, and by the municipal district of Zaidín to the north as shown in Figure 2.

This area, called in Spanish "Parque Tecnológico de la Salud" (PTS), concentrates high-level research, teaching and sanitary services infrastructures and also increasing population in nearby new residential buildings. The biggest hospital in the city, University Hospital San Cecilio; two University of Granada faculties, School of Medicine and School of Health Sciences; even new business, entrepreneurship and innovation centres, endows this urban area a high level of representativeness with respect what 21st-century urbanisation under sustainable development principles should be in Granada. All these infrastructures contribute to the attractiveness of this area for new residents who also appreciate the excellent transport communications provided by a brand new metropolitan train that crosses the area.

The new part of this PTS area, limit to the north-west with the urban consolidated part of the city with new residential buildings, sports facilities, parks and leisure areas as well.

The PTS area was typified as "Sanitary, Educational and Cultural" (SEC) in the acoustic zoning of the city carried out in 2009, where acoustic quality objectives (AQO) are set to Ld=60 dBA, Le=60 dBA and Ln=50 dBA, the lowest in legislation as recommended because of the "sanitary" and "teaching" activities that take place in the area. The northern part of the study area also includes territory typified as "residential" (R) where 5 dBA higher AQO than in

Figure 1: Granada south-east view showing the study area in the foreground, surrounded by the ringway around the city and old part of Granada in the background

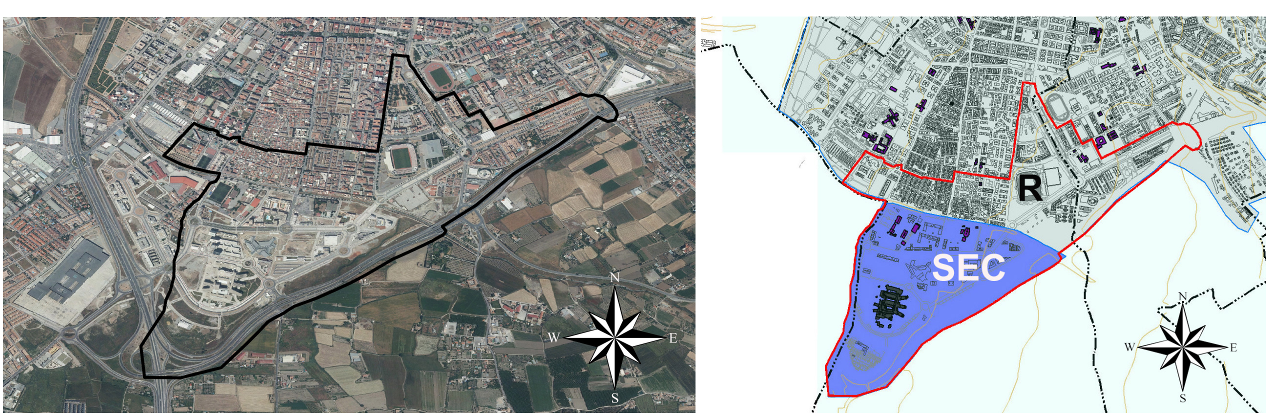

Figure 2: Study area contour (left) and situation within acoustic areas context (right)

SEC territory apply (Ld=65 dBA, Le=65 dBA and Ln=55 dBA). An increasing number of citizens are moving their homes to this area, mainly to new buildings built in the limits between the SEC and R part of the study area (see Figure 2).

As described in [20] heavy traffic flow driving the nearby ringway around the city and noise from University Hospital activities heavily affect the overall complicated acoustic quality of this area, where the lowest legal acoustic quality objectives face the greatest citizens noise exposition in the city. Since noise barriers and other technical solutions are considered insufficient by the local administration, the soundscape approach was adopted. A means of gaining additional knowledge to complement traditional acoustic engineering practices with community advice and participation in urban planning and development.

2.2 Environmental noise context

Information from the city of Granada's 2016 Strategic Noise Map (SNM) give us an overall noise description of the study area as inferred from Ld, Le and Ln noise indicators maps shown in SICA, Noise Pollution Information System, Ministry of Ecological Transition, Government of Spain [3].

In these maps, traffic noise from nearby ringway absolutely dominates and conditionate the situation, summarized in Table 1 taking into consideration the territory above and below legal acoustic quality objectives (AQO) for each indicator. Additionally, the population exposed to environmental noise is presented in Figure 7 with an indication of citizens over AQO as in Table 1.

We observe exceedances over 20 dBA near the ringway and over 15 dBA at almost the whole extension of the corner and the east side of the highway (see Figure 3). This situation determines that the PTS study area is a ZPAE, in Spanish "*Zona de Protección Acústica Especial*" and, according to law, it demands the elaboration of a specific local noise action plan. To do so, as described in [20], environmental noise levels and traffic flows were registered to revise SNM results and see how the situation had progressed since 2016, confirming the given global noise diagnosis of PTS study area.

Figure 3: Study area environmental noise extracted from Granada 2016 Strategic Noise Map. From left to right, up to down: Ld (dBA), Le (dBA), Ln (dBA) and Lden (dBA)

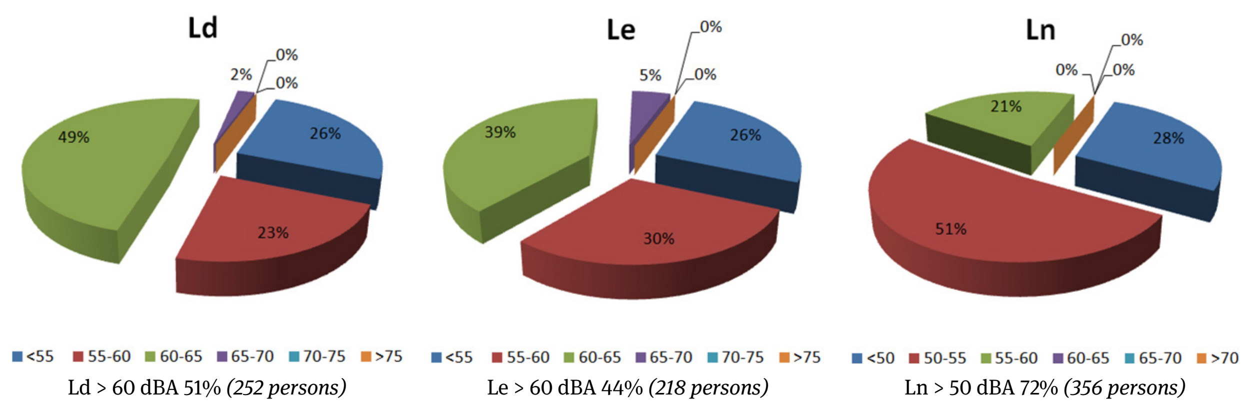

Figure 4: Population exposed to environmental noise ranges as derived from 2016 Granada SNM results, with an indication of people over AQO as in Table 1

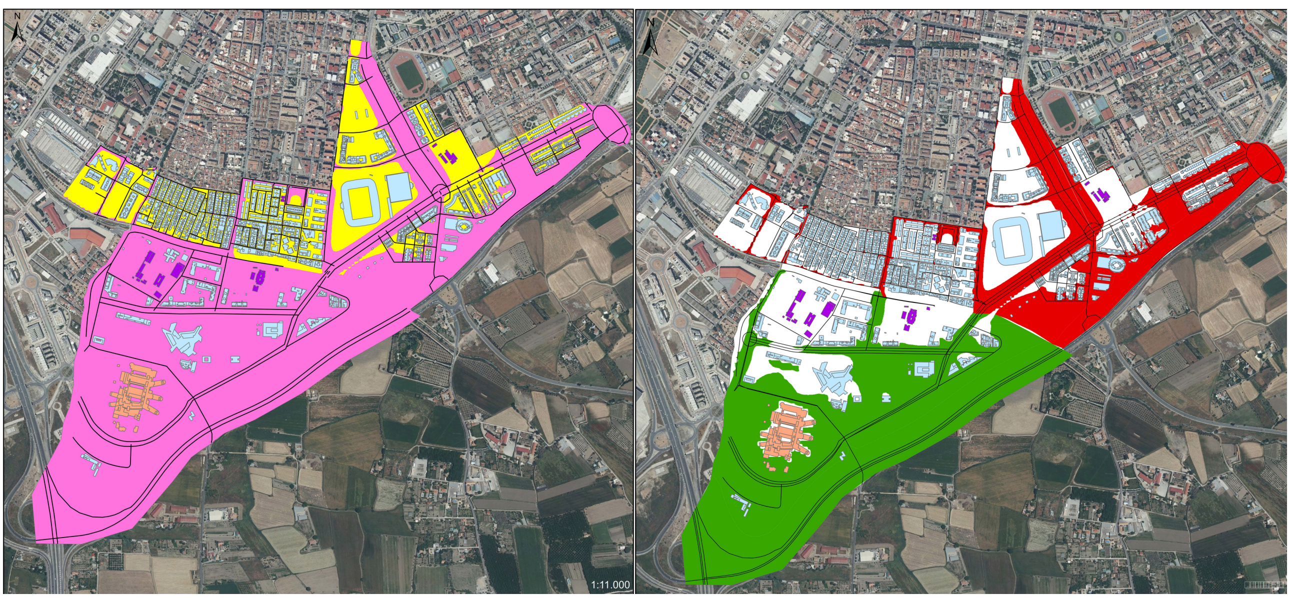

Figure 5: Detailed view of PTS study area (north up, as in Figure 2) in which ZPAE area is marked in pink (left), and MEUA is marked in red (right)

Table 1: PTS study area environmental noise diagnosis from 2016 Granada SNM

PTS Study Area. *Urban area size: 844.336 m^2*			
Indicator	**AQO (dBA)**	**Under AQO**	**Exceeding AQO**
Ld	60	18,8%	81,2%
Le	60	16,1%	83,9%
Ln	50	12,0%	88,0%

If we concentrate on people exposed to noise, the magnitude of the problem has a different interpretation taking into consideration that still few people are living within the study area. In absolute terms, 252 persons during day time, 218 persons during evening period and 356 persons during night time live exposed over AQO limits (51%, 44% and 72% of study area population respectively).

So, when analysing noise conflict areas for the identification of urban territory of interest for noise control, ZPAE areas, in contrast to ZT, in Spanish “*Zona Tranquila*” that delimitates urban areas not exceeding legal limits, the study area is marked as a hotspot in left Figure 5. But when the priority criterion is applied to identify which part of the city deserves to be attended first (in *Noise Action Planning* – NAP) [21], the study area is not the most urgent (*Most Exposed Urban Area* – MEUA), as shown in right Figure 5.

A comparison between daytime and global noise conflict zones yields relevant data. Specifically, there is a part of the PTS that during the day is a conflict zone (ZPAE) while in the global characterization (MEUA) it is qualified as low conflict within conflict, that is, not a priority area for noise control. At the same time, it delimitates a perfect territory for soundscape research before further urbanisation and development take place in the area.

Figure 6: Soundwalk path across PTS study area and photographic description of the eight evaluation stops (P1 to P8)

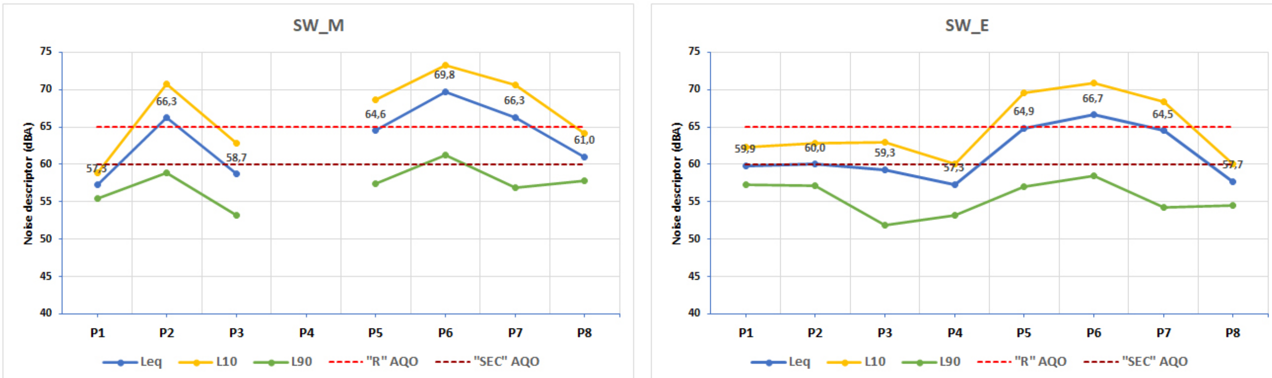

Figure 7: Main noise descriptors and legal acoustic quality objectives during the morning (SW_M) and evening (SW_E) soundwalks at path stops (P1 to P8)

2.3 Procedure and data collection

The assessment was carried out by means of data from a soundwalk across the entire study area together with simultaneous sound level recordings. From the northeastern "Residential" (R) area, characterized by a higher population density and less business activity, to the southeastern "Sanitary, Educational and Cultural" (SEC) area, characterized by just the opposite: less population outside working hours and more business, health and university activity, especially in the mornings. Taking into consideration personal recommendations and works from A. Radicchi [7] and F. Aletta *et al.* [22], the final soundwalk path across the study area was defined including eight stop locations and delimited, as shown in Figure 6 (soundwalk path and photographic description).

In order to analyse differences in soundscape assessment (ZPAE vs MEUA) the soundwalk was repeated twice along the same path, morning and afternoon. It was conducted on different days of the same month and under similar weather conditions. This is the main characteristic that differentiates our work to investigate time dependent factors influencing soundscape evaluations at one site from other researchers that evaluate soundscape across multiple urban spaces as in [14].

The soundwalks took place on a Friday morning (13-04-2018) and later on a Monday evening (23-04-2018) with the same climatology. Fourteen people, 20 to 55 years old (3 women, 11 men; average age 29,3; SD=10,5) participated in the morning soundwalk. Nine people, 20 to 55 years old (3 women, 6 men; average age 34,9; SD=14,1) participated in the evening. Participants were equally distributed in both soundwalks among these groups: university (students taking a degree in Physics and environmental noise researchers), local administration (environmental techniques and Local Agenda 21 techniques) and citizens that attended our invitation. Four men, age 55, 24, 23 and 20 respectively, participated in both soundwalks while the rest of participants were different persons during the morning and evening experiences.

As explained in [20], the group was guided along eight listening stops during the morning walk (identified as SW_M) and evening walk (identified as SW_E) following instructing recommendations by A. Radicchi [7] before, during and after the soundwalks. Stop number 4 could not be completed during morning soundwalk (SW_M; 13/04/2018) because of heavy rain. No incidences took place during the evening soundwalk (SW_E; 23/04/2018)

Coincident environmental noise levels were registered with a Rion NL-52 type 1 sound level meter during ten minutes at every stop, including A-weighted and C-weighted 1 second equivalent noise level and spectral information. Highest environmental noise descriptors were registered at stop location number 6 (P6) both during SW_M and SW_E, while beginning and final soundwalk stops, P1 and P8, presented overall lower values and variations. Figure 7 shows main noise descriptors for SW_M and SW_E together with reference AQO for "Residential" (R) area, affecting stop numbers P1, P2, P3, P4 and P6, and "Sanitary, Educational and Cultural" (SEC) area, affecting stops P5, P7 and P8. Especially significative is the morning-evening environmental noise differences that can be appreciated in the first part of soundwalk path (P1 to P4), not so important in the second part of the itinerary (P5 to P8).

2.4 Soundwalk questionnaire

At the time the soundwalk questionnaire was designed, only part 1 of ISO 12913 was published [12] and there was still a limited consensus on harmonised questionnaires for soundscape research. In Granada it was designed following

Table 2: Soundwalk questionnaire detailed description

No.	QUESTION	SCALE type. Numeric (1-10) or Verbal scale	*Desired information*
Q1	**How often do you visit this place?**	7 pre-defined options	*Occasional/ frequent visit to this place*
Q2	**Describe OVERALL PRESENT SURROUNDING sound environment** *(describa el ambiente sonoro)*	"*very bad*" (1) to "*very good*" (10)	*Overall soundscape appraisal/ sound quality*
Q3	**Is present surrounding sound environment APPROPRIATE to the present place?** *(¿es apropiado?)*	"*not at all*" (1) to "*perfectly*" (10)	*Environmental sound appropriateness*
Q4	**Can you presently HEAR these sounds?** *(¿puede oír?)* *[4.1 traffic, 4.2 persons, 4.3 natural sounds, 4.4 activities and 4.5 other noise sources]*	"*can't hear*" (1) to "*dominant noise*" (10)	*Environmental sound dominance*
Q5	**Present surrounding SOUND ENVIRONMENT IS?** *(el ambiente sonoro es)* *[5.1 pleasant, 5.2 chaotic, 5.3 exciting, 5.4 uneventful, 5.5 calm, 5.6 unpleasant, 5.7 eventful, 5.8 monotonous]*	"*strong disagree*" (1) to "*strong agree*" (10)	*Assessment of emotional components according to Ö. Axelsson et al. model*
Q6	**Please value HOW SUITABLE is this place to practice each of the 15 social/recreational activities listed below** *(valore si es adecuado)* *[outdoor games, appreciate parks and gardens, fishing/navigation, experiencing peace/quiet, experiencing everyday life, sports outdoor individual practice, share time with family/friends, escape city stress, enjoy with inland water like fountains and lakes, talk/chat and social interactions, swimming bathing, walking/jogging, picnic/barbecue, shopping, enjoy cultural heritage like monuments]*	"*not adequate*" (1) to "*really adequate*" (10)	
Q7	**Describe overall present surrounding sound environment QUIETNESS** *(valore la tranquilidad)*	"it is not", "slightly", "moderately", "quiet", "very quiet"	
Q8	**Describe overall present surrounding sound environment PLEASANTNESS** *(valore si es agradable)*	"it is not", "slightly", "moderately", "pleasant", "very pleasant"	*As Q5.1 (numeric scale) but on a verbal basis* *Connected with Q2*
Q9	**Describe overall present surrounding sound environment LOUDNESS** *(valore el ruido)* (volume, magnitude, not quality)	"it is not", "slightly", "moderately", "loud", "very loud"	*Perceived loudness*
Q10	**PERCEIVED LOUDNESS from individual noise sources in this place.** *(sonoridad percibida de distintas fuentes)* *[27 sources divided in Human (3), Mechanic (9), Traffic (4), Geophysics (6) and Biologic (5) noise sources]*	"very low", "low", "normal", "high", "very high"	*Perceived dominance* *Connected to Q4 (numeric scale) but on a verbal scale*

previous experiences in public surveying for noise annoyance determination [21] and works from F. Aletta *et al.* [22] and A. Radicchi *et al.* [23].

This review work led us to 10 main questions with an introduction project page, a demographic info page, and a free creativity drawing page. A detailed description of questions and type of responses are presented in Table 2. Five questions use a numeric (1-10) scale (Q2, Q3, Q4, Q5 and Q6) and four use a 5 items verbal answers scale (Q7, Q8, Q9 and Q10)

Q5 is the main question regarding perceived affective quality, translated into English from original Spanish following O. Axelsson *et al.* [24]. Even though ISO 12913-2 standard [16] had not yet been published at the time of the soundwalk, altogether the questionnaire reasonably matches this standard (or data can be adapted by simple transformation) in the instruction of the participants, the methodology of the procedure and in method A for data collection (Annex C of [16]).

As Table 2 shows original Spanish questionnaire freely translated into English, underlined English terms are also included in bracket original Spanish for better interpretation and understanding.

3 Results and discussion

Following the main objective of this work, that is the characterisation of local environmental and time factors influencing soundscape assessment, we will refer to the first soundwalk during morning period as SW_M and second soundwalk during evening period as SW_E. The eight stops locations will be referred as P1 to P8, and questions will be numbered as Q1 to Q10. Pearson's correlation coefficient and corresponding p-values (r,p) will be given in every stage of the analysis involving correlations between acoustic and soundscape metrics and responses to the questionnaire.

3.1 Overall appraisal and appropriateness

According to Annex A.2 in ISO 12913-3 for the determination of central tendencies of responses in the analysis of data related to soundscape assessment by Method A [17], for all category scales the median values should be reported as the measure of central tendency and the range (highest vs. lowest values span) as the measure of dispersion. This is shown in Table 3 for questions Q2 (*overall appraisal*) and Q3 (*appropriateness*) during morning and evening walks. We have also added information about mean values.

Figures 8 and 9 show mean responses to questions Q2 and Q3 at each stop site together with noise equivalent level descriptor (T=10 minutes, dBA) and percentile levels L10

Table 3: Analysis of answers to questions Q2 (overall appraisal) and Q3 (appropriateness) at stop sites during the morning (SW_M) and evening (SW_E) walks

Soundwalk	Stop	(Q2) Overall APPRAISAL			(Q3) APPROPRIATENESS		
		Mean	Median	Range	Mean	Median	Range
SW_M	P1	4,50	4,0	6	4,29	3,5	7
SW_E		6,11	7,0	6	5,44	6,0	7
SW_M	P2	5,00	5,0	5	6,08	7,0	8
SW_E		6,44	7,0	6	6,67	7,0	7
SW_M	P3	4,93	5,5	5	6,29	5,0	5
SW_E		6,44	7,0	6	7,00	7,0	6
SW_M	P4	*no data*	*no data*	*no data*	*no data*	*no data*	*no data*
SW_E		6,67	7,0	3	7,00	7,0	7
SW_M	P5	5,50	5,5	6	6,14	6,0	8
SW_E		5,00	5,0	6	5,56	5,0	6
SW_M	P6	4,25	3,5	7	4,75	5,0	7
SW_E		3,56	3,0	6	4,78	5,0	6
SW_M	P7	4,07	4,0	6	5,21	6,0	8
SW_E		4,11	4,0	7	5,11	6,0	7
SW_M	P8	4,43	4,0	6	3,86	3,5	6
SW_E		4,89	5,0	5	4,89	5,0	7

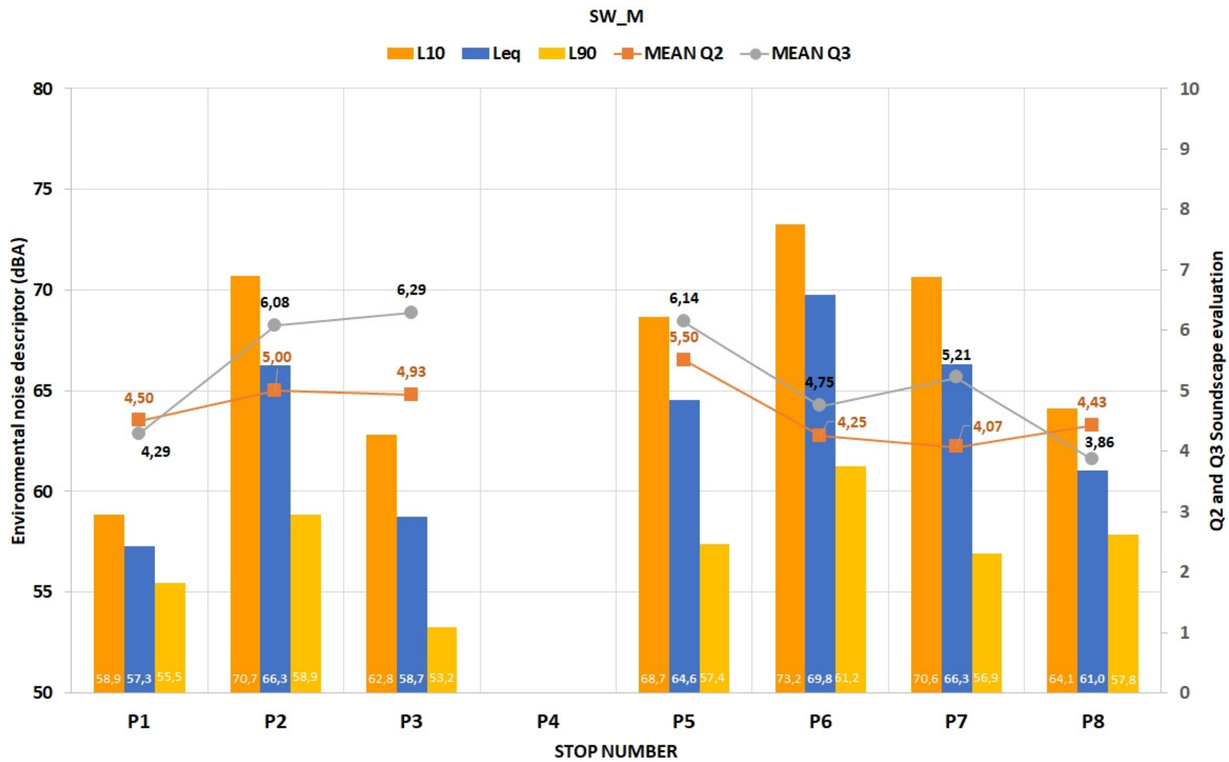

Figure 8: Mean Q2 and Q3 responses and coincident environmental noise characterisation (using LeqT, L10 and L90) at different stop sites during SW_M

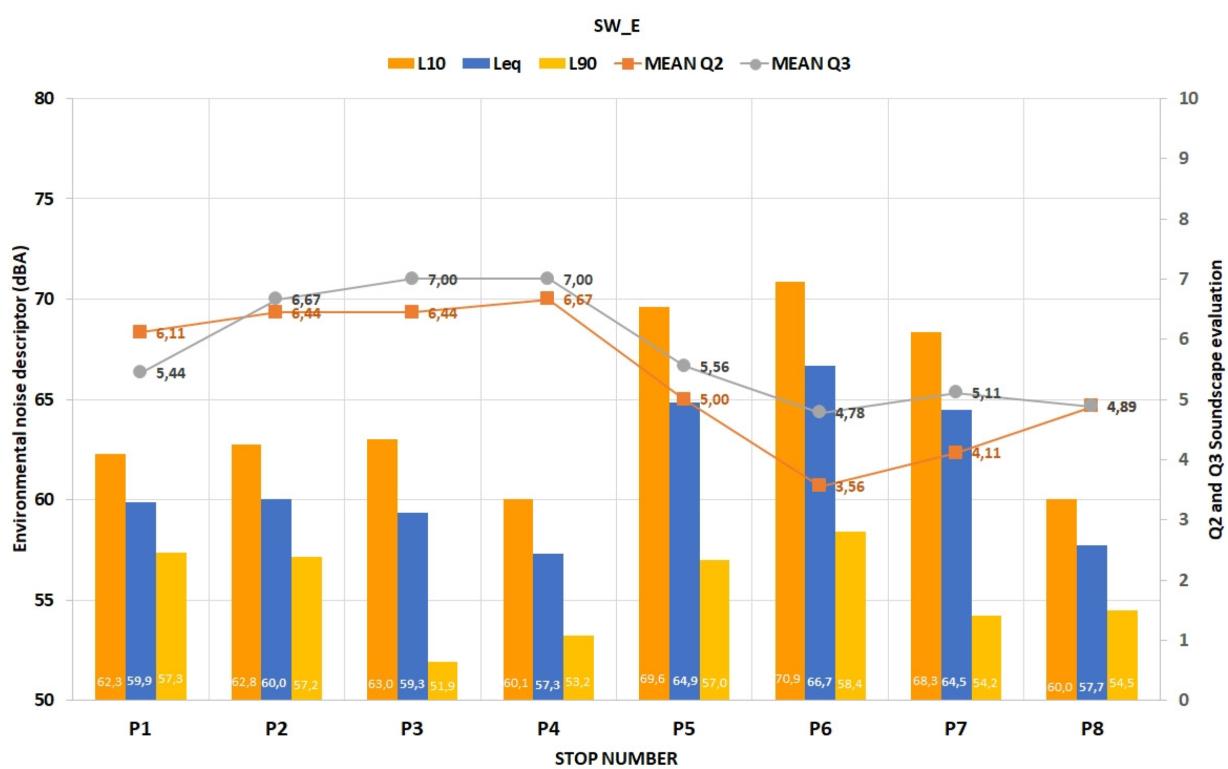

Figure 9: Mean Q2 and Q3 responses and coincident environmental noise characterisation (using Leq, L10 and L90) at different stop sites during SW_E

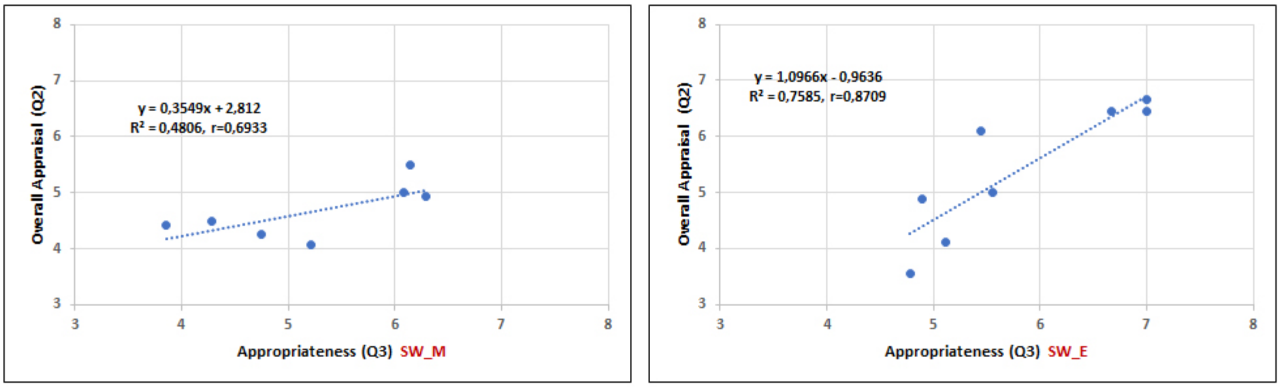

Figure 10: Overall appraisal (Q2) as a function of appropriateness (Q3) during the morning (SW_M) and evening (SW_E) soundwalks

Table 4: Overall sound quality (Q2) and appropriateness (Q3) correlation vs noise descriptors

SW_M			SW_E		
r *(p)*	Q2	Q3	*r (p)*	Q2	Q3
Leq	−0,1548 *(0,740)*	0,1705 *(0,715)*	**Leq**	−0,7865 *(0,021)*	−0,5590 *(0,150)*
Lmax	−0,0892 *(0,849)*	0,2583 *(0,576)*	**Lmax**	−0,7136 *(0,047)*	−0,3658 *(0,373)*
Lmin	−0,1893 *(0,684)*	−0,2636 *(0,568)*	**Lmin**	−0,3885 *(0,342)*	−0,5117 *(0,195)*
L10	−0,0772 *(0,869)*	0,2934 *(0,523)*	**L10**	−0,7537 *(0,031)*	−0,4974 *(0,210)*
L50	−0,3039 *(0,508)*	−0,0820 *(0,861)*	**L50**	−0,6526 *(0,079)*	−0,6129 *(0,106)*
L90	−0,2243 *(0,629)*	−0,2553 *(0,581)*	**L90**	−0,3831 *(0,349)*	−0,5086 *(0,198)*

and L90 (in dBA). From these figures and data in Table 3 it can be observed that mean response to questions Q2 and Q3 increase with lower environmental levels, but not to the same amount nor in the same way. Overall appraisal (Q2) and appropriateness (Q3) improve during the evening at most stops as environmental noise levels drop down, but the evaluation is not better at certain stops even though evening noise levels are lower than in the morning. Altogether, these results are pointing out the importance of site location and local characteristics in soundscape evaluations.

On investigating certain stops, characterized by similar equivalent noise levels during morning or evening soundwalks but quite different evaluations for Q2 and Q3, we realized that overall appraisal and appropriateness get a similar assessment at stop sites characterized by low environmental noise levels and, at the same time, low (L10-L90) difference (as in P1 during SW_M and P8 during SW_E). All this indicates low fluctuations and a stable environmental noise context at those stop sites when the assessment was made.

Figures 8 and 9 also show that overall appraisal (Q2) and appropriateness (Q3) express linked perceptual evaluations as they follow similar evolution over the path during morning and evening. It seems that appropriateness (Q3) is necessary to appreciate an overall good sound quality of the environment (Q2) or vice versa. Our results show a significant positive correlation between mean Q2 and mean Q3 per site as stated by F. Aletta *et al.* [22], but this correlation is greater during SW_E (r=0,8709, p=0,005) and not as important during SW_M (r=0,6933, p=0,084) as shown in Figure 10.

Results seem to confirm that a high level of appropriateness (Q3) are indeed necessary to appreciate an overall good sound quality of the environment (Q2). These two perceptual attributes of the soundscape are especially connected during the evening period when environmental noise condition is characterised by fewer fluctuations and lower levels than in the morning.

Further analysis on how environmental noise descriptors correlate with Q2 and Q3, proved that overall appraisal (Q2) negatively correlates with certain noise descriptors but only during the evening (SW_E). As shown in Table 4, there is a good correlation between Q2 and descriptors Leq, Lmax, L10 and L50, corresponding the highest correlation coefficient to Leq and L10 indices. Appropriateness (Q3) also improves correlation with environmental noise descriptors during the evening, but not reaching significance as shown by p-values much greater than 0,05. Our results for Q2 differ from those of F. Aletta *et al.* [22], stating that L50 presented the highest absolute correlation with subjective judgment of the overall surrounding sound and appropriateness of the environment, as we find in Granada greater relevance of high environmental noise levels (better Lmax and L10 correlation). On the other side, results for appropriateness (Q3) seems to indicate low dependence on environmental noise metrics.

3.2 Environmental sound dominance

Environmental sound dominance was analysed using Q4 in the assessment questionnaire, asking participants if they could hear sounds from selected sources in the precise moment they were doing the evaluation. Assessment by Q4 in our questionnaire is equivalent to part 1 (sound source identification) of Method A in ISO 12913-2 [16]. Traffic noise, sounds from individuals, natural sounds, noise from activities and, finally, other sources not individually considered were included in the questionnaire for which possible answers ranged from "can't hear" to "dominant noise" in a numerical scale from 1 to 10 respectively. Part 1 of Method A in ISO 12913-2 uses five response categories later assigned scale values from 1 to 5 as explained in table A.1 of ISO 12913-3 [17], so our results are easily assimilable. Figure 11 shows results for the morning (SW_M) and evening (SW_E) soundwalks.

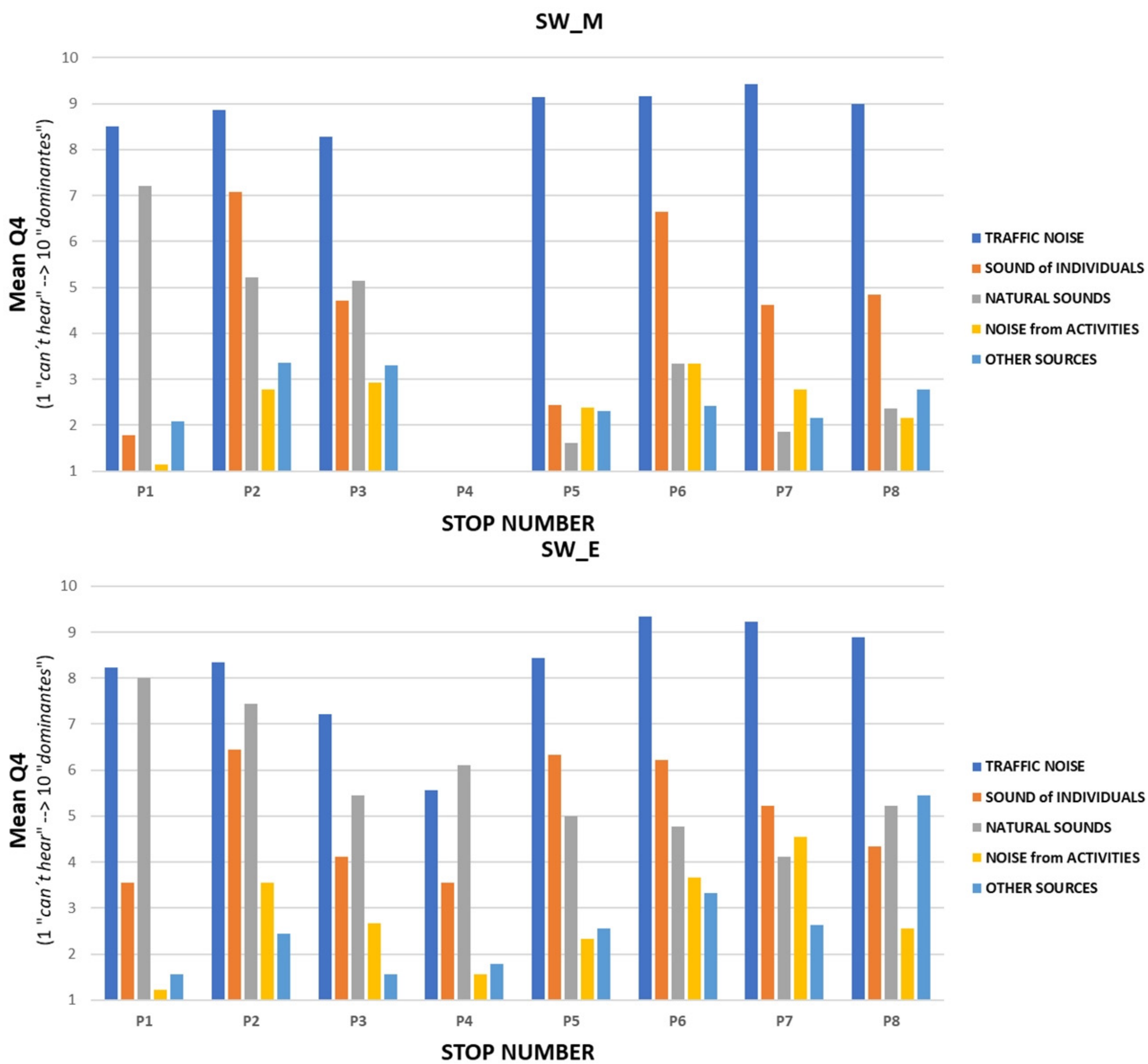

Figure 11: Environmental sound dominance for SW_M (top) and SW_E (down)

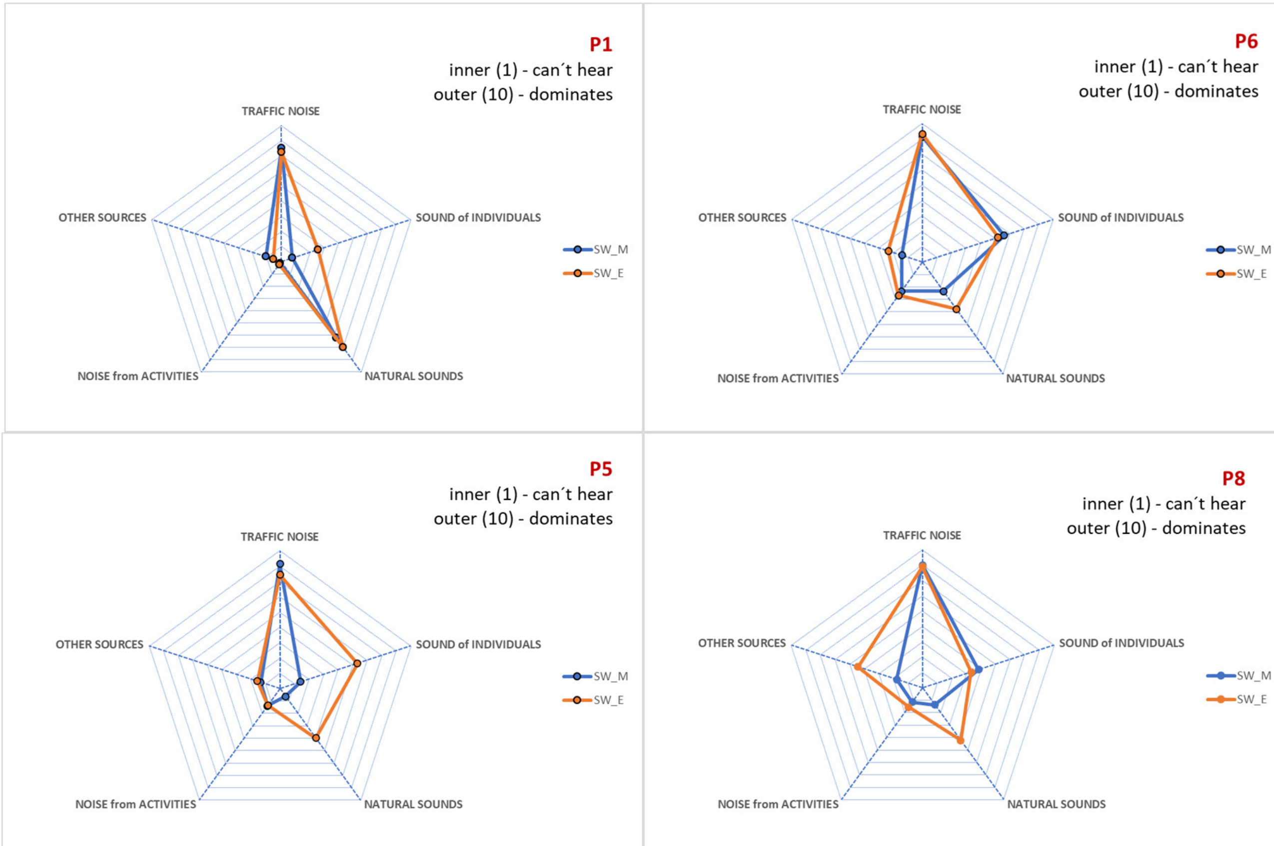

Figure 12: Differences SW_M and SW_E at selected stops within the soundwalk path. P1 and P6 (up) located in (R) urban territory and P5 and P8 at (SEC) territory

Even though traffic noise is always the dominant source, both during morning and evening soundwalks, it is so to a lesser degree during the evening which draws a completely different scenery during this period. Figure 11 shows that traffic noise goes down during SW_E at stops P1 to P3, located in “Residential” (R) territory of the study area, but prevails in similar magnitude at stops P5, P7 and P8 which are located at “Sanitary, Educational and Cultural” (SEC) territory, consequently with great academic and sanitary activity around that area whole day round. Nevertheless, natural sounds and sounds of individuals gain dominance during the evening at every single stop in the path. These results show that important changes take place in the acoustic environment along the day not directly connected with traffic noise, but with the conjunction of factors that make this dominant noise source don’t hide other sources.

Figure 12 shows differences in environmental sound dominance at four selected stops including P1 and P6 located at R territory within PTS study area and P5 and P8 located at SEC territory.

Stops P1 and P6 are relevant because they represent typical residential locations within the study area heavily affected by urban road traffic flows and noise from city life activities, including citizens behaviour and movement. Stops P5 and P8 are relevant because they are locations affected by ringway heavy traffic flows and noise from academic and sanitary buildings nearby. Natural sounds gain dominance at P5, P8 and, to a lesser amount, at P6 during SW_E with respect SW_M. Sounds of individuals experiment minor changes at stops P6 and P8, where more people live and walk around both during morning and evening periods, but gain dominance during SW_E at no so densly populated stops P1 and P5.

Apparently, these results have selective effect in overall appraisal (Q2) and appropriateness (Q3) during SW_E, previously discussed, as we observe that the generalised natural sounds and sounds of individuals greater dominance during SW_E is not traduced in a better assessment at every stop in the path, but only at stops located in “Residential” part of PTS study area. To further investigate this fact, these results will be analysed again in the next section.

3.3 Assessment of emotional components

Assessment of the eight emotional components according to Ö. Axelsson *et al.* model [24] were carried out with question 5 using a numeric scale from 1 to 10 to express the perceived quality of surrounding sound environment, ranging from "*strongly disagree*" to "*strongly agree*" respectively. The eight scales were the same as recommended in Figure C.4 of ISO 12913-2 for part 2 (perceived affective quality) in Method A, including *pleasant (5.1), chaotic (5.2), exciting (5.3), uneventful (5.4), calm (5.5), annoying (5.6), eventful (5.7) and monotonous (5.8)*. Our results, compared to the recommended five response categories and scale values in Table A.1 of ISO 12913-3 (from 5 – *strongly agree* to 1 – *strongly disagree*) have, as before, a direct and easy transformation.

Having in mind the difficulties that could arise among participants in understanding the real meaning of the eight model components, additional information was given in the questionnaire next to each dimension (in Spanish), highlighting main four components *5.1 Pleasant (I like it) vs 5.6 Annoying (it's unpleasant) and 5.7 Eventful (something happens/movement) vs 5.4 Uneventful (static environment), and added components 5.3 Exciting (pleasant and eventful) vs 5.8 Monotonous (annoying and uneventful) and 5.2 Chaotic (annoying and eventful) vs 5.5 Calm (pleasant and uneventful)*. Mean responses to the eight model dimensions from participants during the morning (SW_M) and evening (SW_E) soundwalks at each stop site have been estimated and represented in Figure 13.

Our results show an evident different morning/evening assessment in stops P1, P2 and P3 and similar morning/evening perception in the rest of the path. Urbanisation is almost complete around stops P1 to P4 even though the population is not yet dense in the area, a fact that transforms the local environment, noise sources and the appearance of streets and squares. Contrarily, stops located from mid path to the end, especially stops P7 and P8, lie in an urban territory where urbanisation is still to be fully developed, being non-permanent (transient) populations around hospital and university greater than resident population. Altogether turns in a quite different morning/evening urbanscape that participants in soundwalk noticed as shown in Figure 13.

Comparing in Figure 14 the assessment given by questions Q4 (environmental sound dominance) and Q5 (emotional components) at stops P1 and P3, heavily affected by this different morning/evening evaluation, it seems that "natural sounds" and "sounds of individuals" perception during the evening is not the reason for Q5 results.

Now, as before, the evaluation changes and improves in the residential part of the soundwalk path but, again, the generalised dominance of nature and individuals sound does not seem to be the reason for such differences. Contrast differences were calculated next considering each participant answers to Q5 at each stop, both during SW_M, in which 14 participants took part, and SW_E in which 9 participants collaborated.

Contrast differences (Axelsson *et al.* model components answer differences) of every participant at stop location 3 (P3) are represented in Figure 15 in which "P-Up" refers to the contrast (Pleasant-Unpleasant), "Ch-Cl" to (Chaotic-Calm), "Uv-E" to (Uneventful-Eventful) and "Ex-M" to (Exciting-Monotonous). Contrast differences are computed for each participant as the difference between perception to opposite dimensions (P-Up, Ch-Cl, Uv-E and Ex-M) assigning a scale value ranging from 10 (strongly agree) to 1 (strongly disagree) to the response categories in Q5. Though

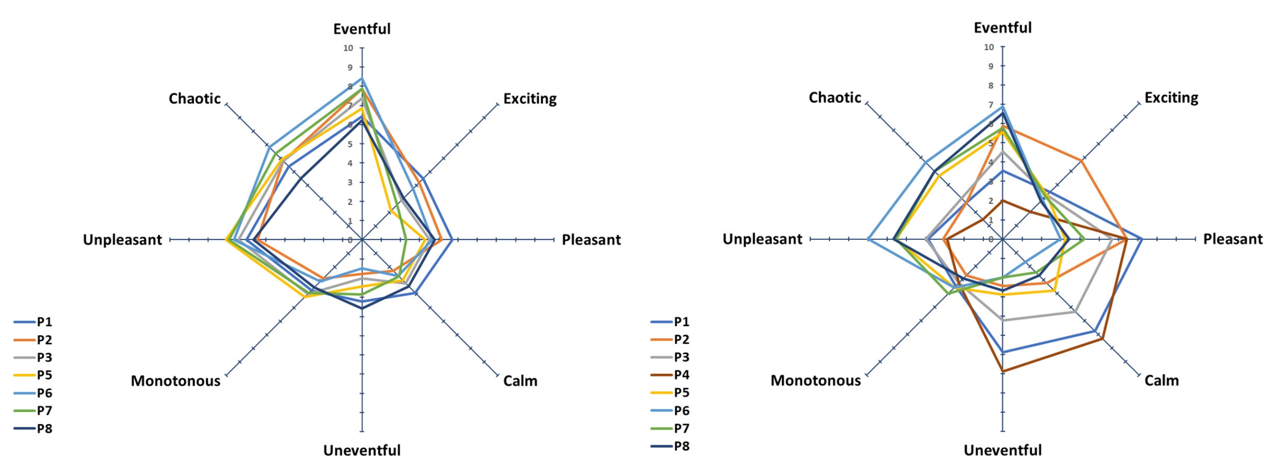

Figure 13: Assessment of emotional components (Q5) at each stop site according to Axelsson *et al.* model (2010) during SW_M (left) and SW_E (right) soundwalks

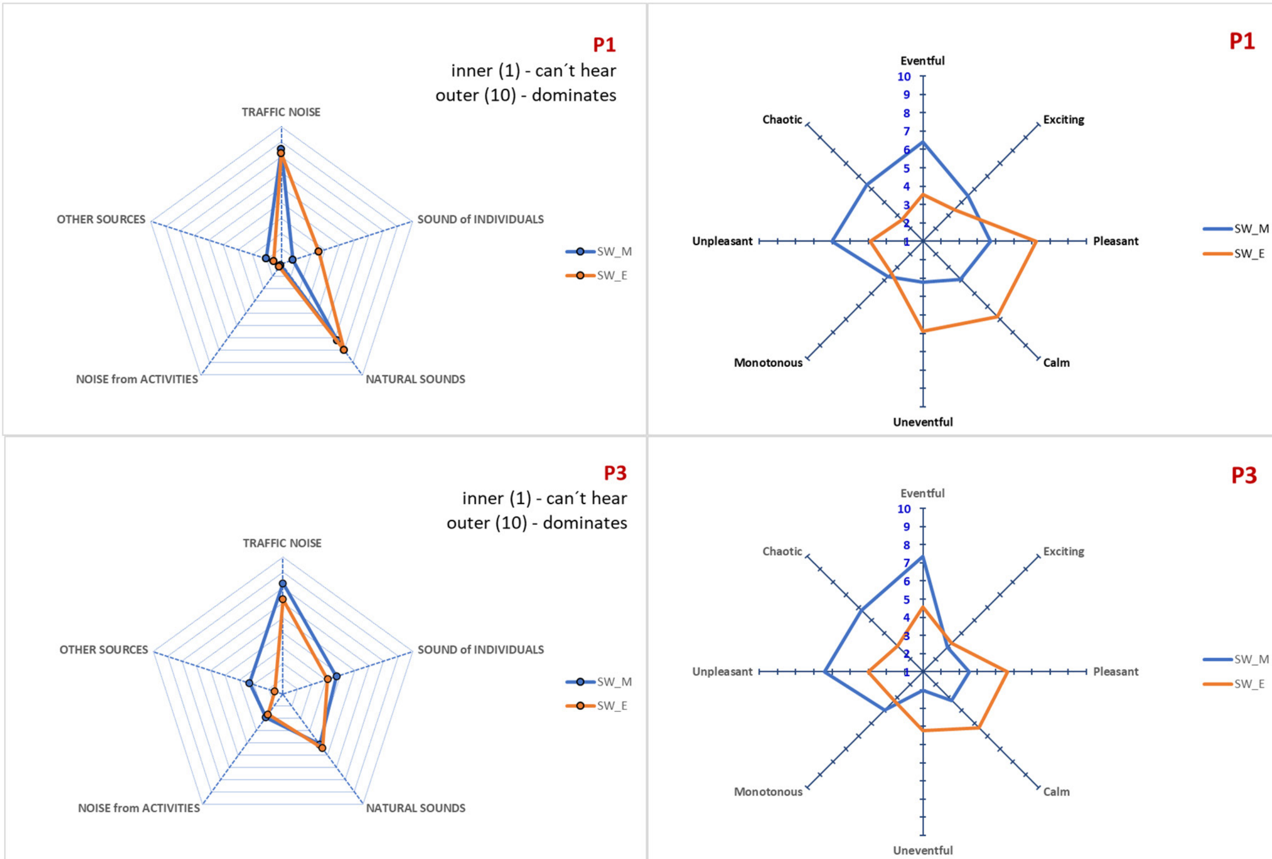

Figure 14: Side by side comparison of assessments at stops number P1 and P3 from questions Q4 (left) and Q5 (right) during morning and evening soundwalks

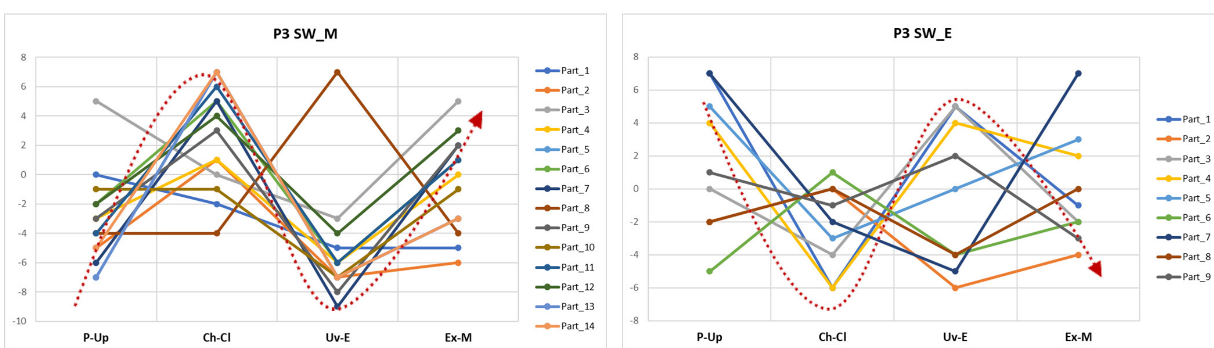

Figure 15: Contrast differences analysis at stop number P3 from collaborators taking part in SW_M (14 participants) and SW_E (9 participants) soundwalks. The dotted red line indicates change tendency from "annoying-chaotic-eventful" soundscape (left) in the morning to a more "pleasant-calm-uneventful" interpretation in the evening (right)

some participants collaborated in both soundwalks, the designation on the right does not correspond to the same participants (for example, Part_3 during the morning is not the same as Part_3 during the evening). We can see how the perceived affective quality in P3 moves from a somewhat "annoying-chaotic-eventful" soundscape to a more "pleasant-calm-uneventful" interpretation. High variations in contrast differences are also observed during the evening, which indicates that the evaluation of emotional model components is highly affected by factors that are no so evident during the morning but gain importance during the evening.

A similar change is observed in stops P1 and P2 and to a lesser extent in stop number P5, evidencing that typical "upper left side" assessment, as that during the morning in Figure 15 left graph, moves to a "lower right side" perception during the evening as that in Figure 15 right graph. An evolution indicating that different morning/evening local characteristic rather than dominant noise sources changes would be the main reason for this perception.

To better understand this data behaviour, we have attended ISO 12913-3 recommendation in Annex A.3 regarding affective responses and its representation in a two-dimensional model (figure A.1 in ISO 12913-3, [17]), just as in Figure 13, except that dimensions "*Exciting*" and "*Unpleasant"* in Axelsson's *et al.* model are respectively written as "V*ibrant*" and *"Annoying"* in ISO 12913-3. In this type of representation, the two main dimensions are how pleasant or annoying (unpleasant) the environment was judged and the amount of activity (human or another type) experienced around, that is how eventful or uneventful the acoustic environment was perceived. According to ISO 12913-3, "pleasantness", designed as "P", is the magnitude representing the first main dimension and "eventfulness", designed as "E", the second one and both can be calculated, respectively, employing formulae A.1 and A.2 when emotional components are given a scale value from 5 to 1 as in Table A.1, Annex A, ISO 12913-3 [17].

The coordinate for pleasantness, P, and eventfulness, E, are estimated from formulae A.1 and A.2 in [17] as followws:

$$P = (p - a) + \cos 45^\circ \cdot (ca - ch) + \cos 45^\circ \cdot (v - m)$$

$$E = (e - u) + \cos 45^\circ \cdot (ch - ca) + \cos 45^\circ \cdot (v - m)$$

in which a is "annoying", ca is "calm", ch is "chaotic", e is "eventful", m is "monotonous", p is "pleasant", u is "uneventful" and v is "vibrant".

Transforming our data accordingly, and changing the range of formulae to +/−1 dividing by 9,657, as suggested in page 5 ISO 12913-3, pleasantness "P" and eventfulness "E" were estimated for SW_M and SW_E, as shown in Figure 16, a preferred representation of data shown in Figure 13.

As it would be expected, higher values of eventfulness explain lower values of pleasantness during the morning soundwalk and, contrarily during the evening, lower eventfulness gives higher pleasantness. Out of these, results in P2 are some kind of surprising as P and E are almost coincident during the evening, highlighting once again the importance of the local environment in the evaluation as stop P2 present similar results as P1 and P3 during the morning, but an a priori unexpected result during the evening. Comparison SW_M vs SW_E for "pleasantness" and "eventfulness" is shown in Figure 17.

It can be seen that pleasantness increases at every stop from morning to evening as eventfulness decreases accordingly, except at P6 and P8. The situation at P2 is especially remarkable as it experiments a similar improvement of pleasantness as in P1, but it doesn't follow a similar decrease in eventfulness during the evening. Special characteristics affect P2 during evening nevertheless its proximity to P1. Something that would never be assumed from environmental noise descriptors, quite similar as those in P1 (as it can be observed in Figure 9), that makes this stop gain overall appraisal (Q2) and appropriateness (Q3) (see Figure 9) and pleasantness, even though a lower change in eventfulness as seen in Figure 17. Similar comments apply to P6 and P8, affected by multiple factors changing local characteristics from morning to evening that does not rely solely on environmental noise descriptors or the dominance of specific noise sources like traffic or sound from nature or individuals. In the case of P2, we think that the big fountain and roundabout (see Figure 6) together with the nearby metropolitan rail traffic makes the difference. Stop P6 is heavily affected by its proximity to the border of R and SEC territory delimitation with dense low-speed road traffic and dense people walking around and near open spaces. Finally, stop P8 is affected by ring-road traffic flows and, especially, activity from hospital and university at a near distance.

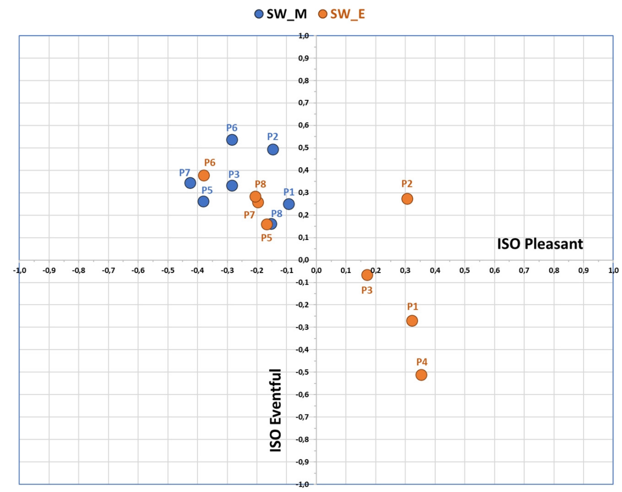

Figure 16: Pleasantness (P) and Eventfulness (E) as derived from ISO 12913-3 formulae and Q5 data at every stop in the path during SW_M and SW_E

Correlation between the eight sound attributes in Axelsson *et al.* model and noise descriptors was next analysed, finding that "*chaotic*" and "*eventful*" present positive correlation against Leq, Lmax and L10 during the morning, and opposite feelings "*calm*" and "*uneventful*" negative correlation with these descriptors (absolute r > 0,6) But only "*eventful*" and "*calm*" correlations have significative p-vale under 0,05 (see Table 5).

Table 5: Correlation between sound attributes in Axelsson et al. model (perceived affective quality) and noise descriptors

MORNING (r, p)	**Pleasant**		**Chaotic**		**Exciting**		**Uneventful**		**Calm**		**Unpleasant**		**Eventful**		**Monotonous**	
Leq	−0,4492	*0,312*	**0,6963**	*0,082*	−0,1297	*0,782*	**−0,5754**	*0,176*	**−0,8599**	***0,013***	0,3093	*0,500*	**0,7856**	***0,036***	−0,4491	*0,312*
Lmax	−0,4534	*0,307*	**0,7800**	***0,039***	−0,1429	*0,760*	**−0,6341**	*0,126*	**−0,8520**	***0,015***	0,3999	*0,374*	**0,8144**	***0,026***	−0,3777	*0,404*
Lmin	0,0373	*0,937*	0,2955	*0,520*	0,2011	*0,665*	−0,3321	*0,467*	−0,5477	*0,203*	−0,0898	*0,848*	0,4277	*0,338*	−0,6999	*0,080*
L10	−0,5233	*0,228*	**0,6916**	*0,085*	−0,2196	*0,636*	**−0,6084**	*0,147*	**−0,9149**	***0,004***	0,3263	*0,475*	**0,8011**	***0,030***	−0,3927	*0,384*
L50	−0,3519	*0,439*	0,6182	*0,139*	−0,0384	*0,935*	−0,4405	*0,323*	−0,7115	*0,073*	0,2657	*0,565*	0,6854	*0,089*	−0,4970	*0,257*
L90	−0,0089	*0,985*	0,3518	*0,439*	0,1931	*0,678*	−0,3365	*0,461*	−0,5701	*0,181*	−0,0418	*0,929*	0,4682	*0,289*	−0,6827	*0,091*
EVENING (r,p)	**Pleasant**		**Chaotic**		**Exciting**		**Uneventful**		**Calm**		**Unpleasant**		**Eventful**		**Monotonous**	
Leq	**−0,6256**	*0,097*	**0,7136**	***0,047***	0,0280	*0,948*	**−0,6283**	*0,095*	**−0,6233**	*0,099*	**0,7365**	***0,037***	**0,5592**	*0,150*	**0,6813**	*0,063*
Lmax	**−0,6316**	*0,093*	**0,6664**	*0,071*	−0,0590	*0,890*	**−0,6240**	*0,098*	**−0,5953**	*0,120*	**0,6742**	*0,067*	**0,5056**	*0,201*	**0,7094**	***0,049***
Lmin	−0,2110	*0,616*	0,3469	*0,400*	0,4091	*0,314*	−0,3587	*0,383*	−0,3879	*0,342*	0,3610	*0,380*	0,4366	*0,279*	0,0095	*0,982*
L10	**−0,6411**	*0,087*	**0,6947**	*0,056*	−0,0025	*0,995*	**−0,6102**	*0,108*	**−0,5945**	*0,120*	**0,7203**	***0,044***	**0,5310**	*0,176*	**0,6856**	*0,061*
L50	−0,4866	*0,221*	0,5824	*0,130*	0,1710	*0,686*	−0,4903	*0,217*	−0,5273	*0,179*	0,6329	*0,092*	0,5284	*0,178*	0,3399	*0,410*
L90	−0,1846	*0,662*	0,3339	*0,419*	0,4007	*0,325*	−0,3339	*0,419*	−0,3604	*0,380*	0,3554	*0,388*	0,4116	*0,311*	0,0448	*0,916*

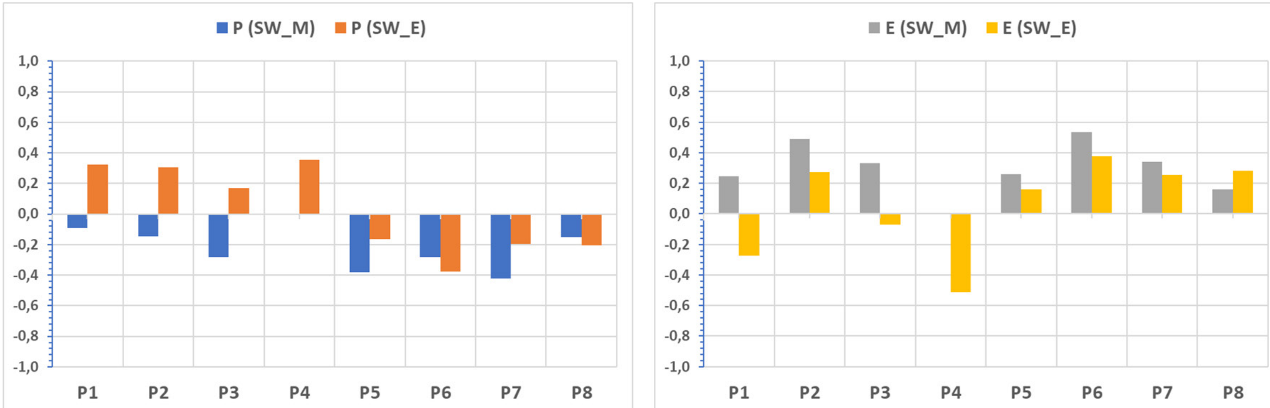

Figure 17: Pleasantness (P, left) and Eventfulness (E, right) morning vs evening comparisons at every stop in the path during soundwalks

On the contrary, during the evening all except "*exciting*" correlates (absolute r > 0,6 except "*eventful*" for which r > 0,5) with Leq, Lmax and L10, negatively for "*pleasant*", "*uneventful*" and "*calm*" and positively for the rest of the components, being "*unpleasant*" the dimension with more significative p-values (see Table 5).

We may conclude that lower environmental noise during the evening gives a much better overall appearance of the city, driving participants towards the perception of pleasantness and calmness and less annoyance as the main factor affecting the global evaluation during SW_E. On the contrary, higher levels may affect perception towards feelings of chaos and eventfulness, altogether highlighting the importance of time and local ambient in soundscape evaluations.

Finally, similar correlation analysis was performed between Q4 and Q5 answers as shown in Table 6. "Traffic noise" was found to be positively correlated with "*chaotic*", "*unpleasant*" and "*eventful*" and negatively correlated with "*uneventful*" and "*calm*" but only during the evening walk (see Table 6)

On the other hand, "Sound of Individuals" was found to correlate with "*eventful*" during the evening walk but be negatively correlated with "*calm*" in the morning and the evening.

"Natural sounds" positive correlates with "*pleasant*" both in the morning and the evening and with "*exciting*" in the morning but negatively with "*chaotic*" and "*unpleasant*"during the evening.

These results are in accordance with observations about differences in perceived affective quality in the morn-

Table 6: Best correlation results for selected sound dominance (Q4) and perceived affective quality (Q5) components during morning and evening soundwalks

	SW_E	**SW_E**	**SW_E**	**SW_E**	**SW_E**
Traffic noise (Q4.1)	***Chaotic* (Q5.2)**	***Unpleasant* (Q5.6)**	***Eventful* (Q5.7)**	***Uneventful* (Q5.4)**	***Calm* (Q5.5)**
	r = 0,8553	r = 0,7633	r = 0,8838	r = −0,8435	r = −0,8401
	p = 0,007	*p = 0,028*	*p = 0,004*	*p = 0,008*	*p = 0,009*
	SW_M	**SW_E**	**SW_M**	**SW_E**	
Sound of Individuals (Q4.2)	***Eventful* (Q5.7)**		***Calm* (Q5.5)**		
	r = 0,7104	r = 0,7210	r = −0,7678	r = −0,7523	
	p = 0,074	*p = 0,044*	*p = 0,044*	*p = 0,031*	
	SW_M	**SW_E**	**SW_M**	**SW_E**	**SW_E**
Natural sounds (Q4.3)	***Pleasant* (Q5.1)**		***Exciting* (Q5.3)**	***Chaotic* (Q5.2)**	***Unpleasant* (Q5.6)**
	r = 0,7855	r = 0,8327	r = 0,8195	r = −0,7163	r = −0,7170
	p = 0,036	*p = 0,010*	*p = 0,024*	*p = 0,046*	*p = 0,045*

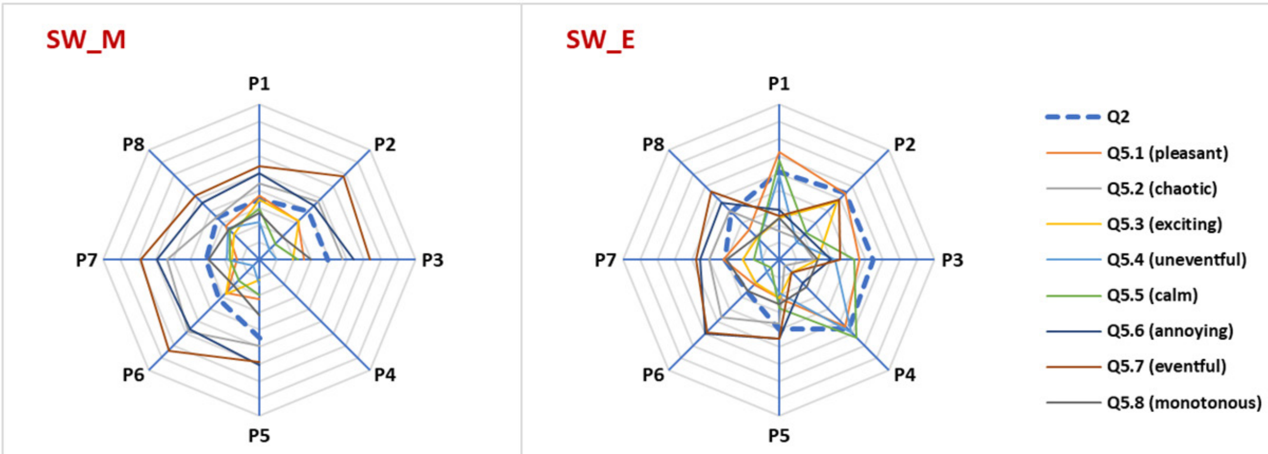

Figure 18: Mean overall appraisal (Q2 answers) together with mean Q5 answers at every soundwalk stop [P1 to P8] during SW_M (left; no data at P4) and SW_E (right)

ing vs evening, as natural sounds and sounds of individuals would "move" the Q5 assessment towards the sector "pleasant" and "calm" as "unpleasant" and "chaotic" would lose prominence during SW_E.

These results disagree with those of Aletta *et al.* [22] concerning humans and calmness but agree in the other components. Similar results are found as in Kang *et al.* [8] for the positive influence of natural sounds in the evaluation of environmental pleasantness or traffic noise as a negative factor for pleasantness.

Finally, if we compare results from Q5 against Q2 (overall appraisal), we find again important differences between morning and evening soundwalks, being the most important that the overall appraisal of the environment (Q2) is closer to emotional component Q5.1 "*pleasant*" and, to a lesser extent, to Q5.5 "*calm*" and Q5.3 "*exciting*" especially during the evening.

On the other hand, Q5.2 "*chaotic*", Q5.6 "*unpleasant*" and Q5.7 "*eventful*" are the emotional evaluation of the environment quite distant from its overall sound quality assess by Q2, as shown in Figure 18.

3.4 Soundscape assessment by non-ISO standard

Analysis of answers from questions Q7, Q8 and Q9 follow. These three questions are rated on 5 verbal response categories interested in overall quietness (Q7), pleasantness (Q8) and loudness (Q9). It should be noted that "*quietness*" means the free translation of the original Spanish word in questionnaire "*tranquilidad*", the same way as "*pleasantness*" refers to "agradable" in Spanish and, finally, "*loudness*" refers to "*volumen del ruido*" in Spanish questionnaire. So, these questions were not formulated according to ISO 12913 standard recommendations but, instead, followed works and recommendations from Aletta [22] and Radicchi [23]. Nevertheless, there are some complementary connections among questions, which was the reason to include them in questionnaire for later analysis purposes: question Q7 (overall quietness) could be considered connected to question/answer 5.5 "Calm" and question Q8 (overall pleasantness) would be connected both to question/answer 5.1 "Pleasant" and question Q2 (overall appraisal).

Results show that Quietness (Q7) positively correlates with (Q8) pleasantness and negatively with (Q9) loudness,

Table 7: Pearson's correlation coefficient and corresponding p-values (r,p) analysis for Q7 (quietness) vs Q8 (pleasantness) and Q9 (loudness) and Q8 vs Q9 during morning and evening soundwalks

r *(p)*		**pleasantness** (Q8)	**loudness** (Q9)
quietness (Q7)	SW_M	0,6207 (0,137)	−0,7072 (0,076)
	SW_E	0,9482 (< 0,001)	−0,8843 (0,004)
pleasantness (Q8)	SW_M		−0,5123 (0,240)
	SW_E		−0,8290 (0,011)

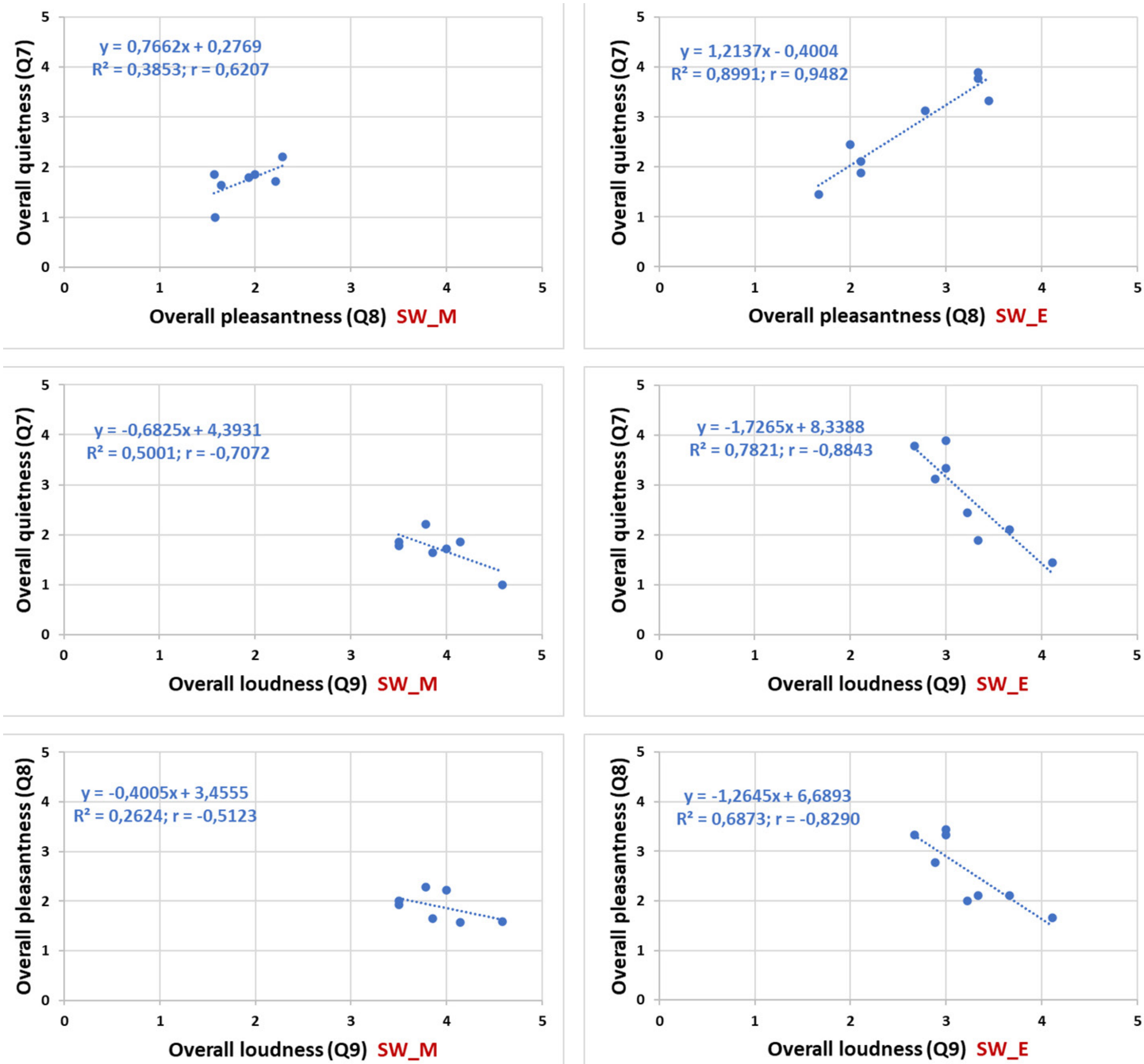

Figure 19: Overall quietness (Q7), pleasantness (Q8) and loudness (Q9) correlations during the morning (left) and evening (right) soundwalks

but the correlation is much better during the evening both for Q8 and Q9 as shown in Table 7. On the other hand, pleasantness (Q8) presents a weak negative correlation with loudness (Q9) during the morning that, once again, increases considerably during the evening (Table 7).

Overall loudness (Q9), which refers to environmental noise magnitude, volume, not quality, appears as quite responsible for the overall feeling of quietness and pleasantness, a perception that strengthens during the evening as shown in Figure 19, when peaks and maximums in a lower environmental noise background generate greater annoyance and correlations show better results (minor relevance during the morning).

Contrarily, similar correlations during morning and evening are found between these magnitudes and noise metrics as shown in Table 8. Overall quietness (Q7) negatively correlates with most descriptors except background noise (Lmin and L90) during the evening (p-value > 0,5). Pleasantness (Q8) doesn't present good coefficients during the morning, but it presents certain negative correlation with Leq, Lmax and L10 during the evening (small p-values but > 0,05). Finally, overall loudness (Q9) correlates with every descriptor and period, except for L90 and Lmin de-

Table 8: Overall quietness (Q7), pleasantness (Q8) and loudness (Q9) correlation vs noise descriptors [Pearson's correlation coefficients (r) and p-value (p)]

	SW_M				SW_E		
r (p)	**Q7**	**Q8**	**Q9**	***r (p)***	**Q7**	**Q8**	**Q9**
Leq	**−0,8115**	**−0,6498**	**0,8490**	**Leq**	**−0,8048**	**−0,6559**	**0,8810**
	(0,027)	*(0,114)*	***(0,016)***		***(0,016)***	*(0,077)*	***(0,004)***
Lmax	**−0,7976**	**−0,6588**	**0,8755**	**Lmax**	**−0,8157**	**−0,6722**	**0,7459**
	(0,032)	*(0,108)*	***(0,010)***		***(0,014)***	*(0,068)*	***(0,034)***
Lmin	**−0,7856**	−0,3562	**0,7077**	**Lmin**	−0,2806	−0,1646	**0,6367**
	(0,036)	*(0,433)*	*(0,075)*		*(0,501)*	*(0,697)*	*(0,090)*
L10	**−0,7819**	**−0,6568**	**0,7785**	**L10**	**−0,8047**	**−0,6609**	**0,8634**
	(0,038)	*(0,109)*	***(0,039)***		***(0,016)***	*(0,074)*	***(0,006)***
L50	**−0,8303**	**−0,6491**	**0,8812**	**L50**	−0,5909	−0,4707	**0,8756**
	(0,021)	*(0,115)*	***(0,009)***		*(0,123)*	*(0,239)*	***(0,004)***
L90	**−0,7799**	−0,3898	**0,7572**	**L90**	−0,2664	−0,1505	**0,6333**
	(0,039)	*(0,387)*	***(0,049)***		*(0,524)*	*(0,722)*	*(0,092)*

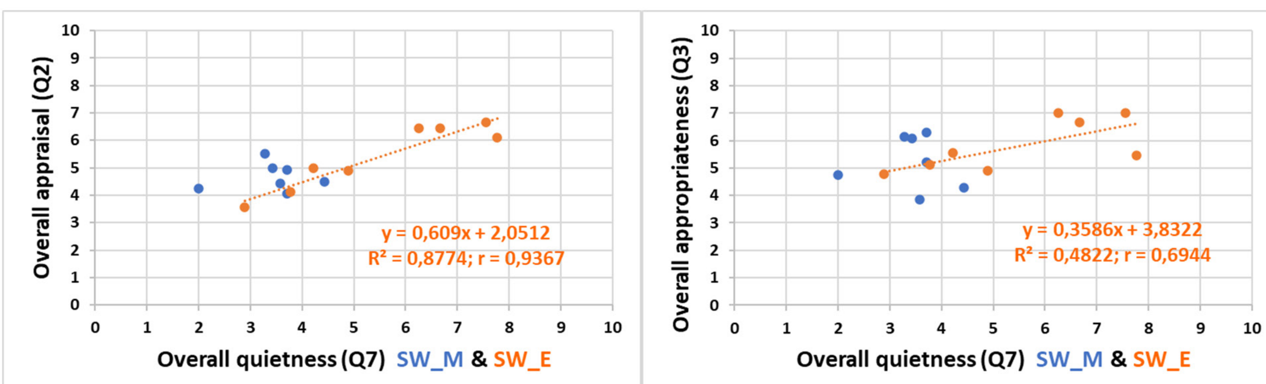

Figure 20: Evening correlation data for Q2 (appraisal, left) and Q3 (appropriateness, right) vs Q7 (quietness) graphed as orange dots and fit equations, compared with morning data (dots in blue) for which there is no correlation

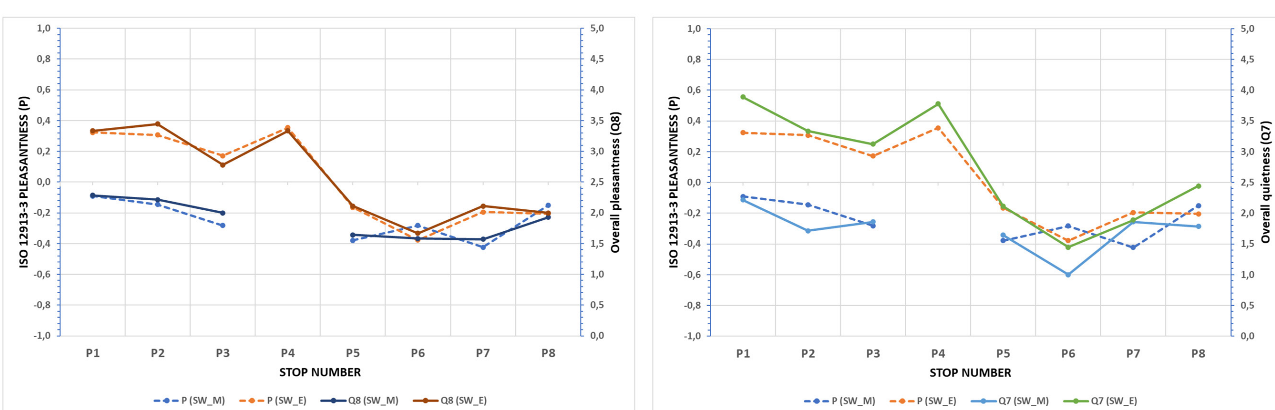

Figure 21: Pleasantness "P" estimated according to ISO 12913-3 2019 and overall mean pleasantness (Q8, left) and quietness (Q7, right) at every stop during morning and evening soundwalks

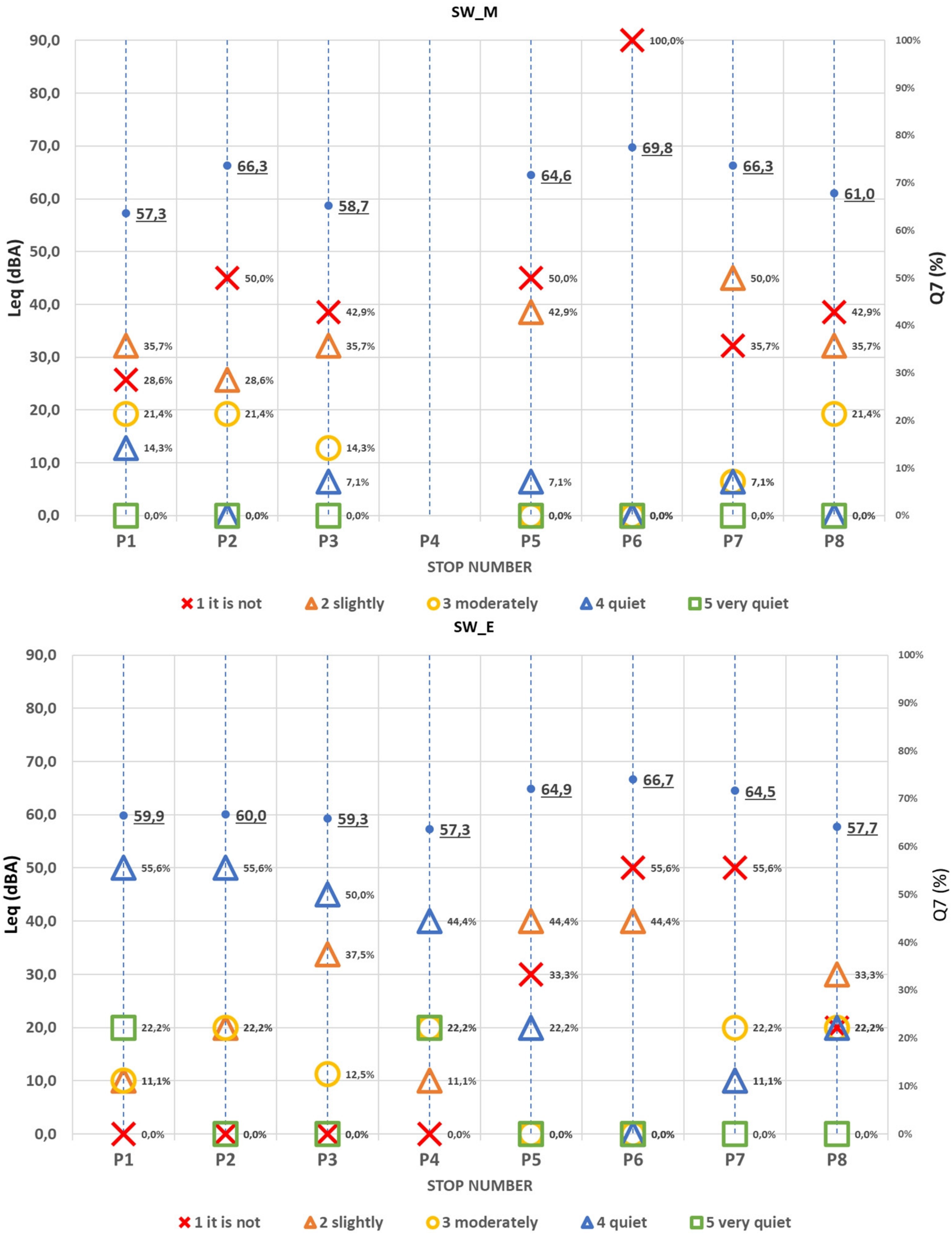

Figure 22: Percentage distribution of the five ordinal-category scale answers to question Q7 (overall quietness, right axis) and equivalent noise level descriptor (left axis) at every stop in path during the morning (up) and evening (bottom) soundwalks

scriptors, which appears as a reasonable result. Altogether, noise indicator Leq and Lmax seem to be good and stable indicators in most cases in this assessment.

General sound quality (Q2) and appropriateness (Q3) do not correlate at all with Q7, Q8 or Q9 (overall quietness, pleasantness and loudness respectively) during the morning walk, but they do during the evening. Q2 correlates positively with Q7 (r=0,9367, p=0,001) and Q8 (r=0,9145, p=0,001) and negatively with Q9 (r=−0,8836, p=0,004). On the other hand, appropriateness Q3 somehow correlates positively with quietness Q7 (r=0,6944, p=0,056) and, more significantly, with pleasantness Q8 (r=0,7549, p=0,030) and negatively with loudness Q9 (r=−0,7437, p=0,034).

This fact highlights the importance of background levels and city life agitation in the perception and interpretation of the urban soundscape. It can also be pointing out the importance given by citizens to less noisy environments during the evening and the tolerance to high levels during the morning.

The results also point out the importance of questions like Q7 (overall quietness) or Q8 (overall pleasantness) as they represent valuable contrast elements for decision-making complementing other assessment data that could be, occasionally, misunderstood. In this sense, Q8 closely reproduces ISO 12913-3 pleasantness "P" as shown in Figure 21, making it a good alternative, better than Q7, if emotional data are not available.

Additionally, Figure 22 shows how answers to Q7 distribute along with information on noise equivalent descriptor, giving a full description of how they complement to understand the big changes that take place during the evening at certain stops that would keep undetected under traditional environmental noise data or limited perception data. Mean overall quietness at every stop is shown in Figure 21.

3.5 Perceived dominance of individual sources

Answers from question Q10 "*Perceived intensity from different noise*" (perceived dominance) on a five items verbal scale, complements question Q4 about "*Environmental sound dominance*" on a (0-10) numeric scale. Sounds from adults dominate "Human" noise sources during the morning and evening, sounds from bicycles moving around and emergency vehicles dominate "Mechanic" noise and near road traffic noise clearly dominates "Traffic" noise sources followed by motorcycles especially during the evening. Birds flying around dominates "Biologic" noise sources and vegetation and water are the main "Geophysics" noise sources. The most important conclusion from Q10 is that pleasantness (Q8) positively correlates with birds and movement of vegetation and trees to a greater extent during mornings than evenings and negatively correlates with motorcycles but only during evenings, which reinforce previous results on greater tolerance to noise during the morning period.

4 Conclusions

Soundscape approach applied to a new urban area affected by high road noise levels and growing urbanization pressure contributes to a better knowledge and, to some extent, characterization of noise issues taking into consideration human perceptions. But this research also shows important differences in the perceived quality of the acoustic environment along the day, that is, time factors affecting soundscape assessment, and along the sound path itself, that is, local environmental issues affecting how sounds are perceived by people.

The main conclusion is that soundscape assessment should not be carried out by single evaluations limited in space and time, but repeatedly over long periods and at different times of the day and different dates in the year if soundwalk techniques are going to be applied. If auditions are to be used for soundscape characterizations, enough sound sources representing a wide variety of local conditions and acoustic environments should be used, especially in conflict context such as PTS study area analyzed in this work.

After that, our results show that high level of appropriateness is necessary to appreciate an overall good sound quality of the environment and that overall loudness appears as responsible for the feeling of quietness and pleasantness, a perception that strengthens during the evening.

Personal judgment about the overall surrounding sound environment shows greater tolerance to high environmental levels during the morning. The overall appraisal of the environment is found to be closer to the emotional component "*pleasant*" and, to a lesser extent, to "*calm*" and "*exciting*" especially during the evening. All these findings should be taken into account when designing the new urbanisation of the area, to incorporate all those urban elements that reduce environmental noise relevance and increments overall good appraisal of the environment. The elaboration of noise control plans should also consider these results, as great differences between morning and evening have been found connected to subjective judgment rather than to environmental noise levels in the area.

Acknowledgement: This original work was carried out with the collaboration of Granada City Council Local Agenda 21 Technical Office in the execution of the soundwalks. Authors are grateful to the participants in the soundwalks and appreciate their interesting discussion and feedback. Valuable comments and personal feedback from Antonella Radicchi and Francesco Aletta are highly appreciated.

Funding information: The authors state no funding involved.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest: The authors state no conflict of interest.

References

[1] Herrera O, Serrano S, Ruiz DP, Vida Manzano J. Mapa estratégico de ruido de la ciudad de Granada; 2008. http://sicaweb.cedex.es/ume-fase1.php?id=259
[2] Vida Manzano J, Puga JL, León-Martín LM. LORCA, Limitación, cOntrol y Reducción de la Contaminación Acústica en Granada; 2013. http://sicaweb.cedex.es/docs/planes/Fase2/Aglomeraciones/PAR_Granada.pdf
[3] Olivares A, García AJ, Martínez J, Escobar R, López CM, Gutiérrez M and Vida Manzano J. Mapa Estratégico de Ruido de la Ciudad de Granada; 2016. http://sicaweb.cedex.es/ume-fase3.php?id=17
[4] Covenant of Mayors for Climate & Energy EUROPE. Signatory city Granada (Spain). https://www.covenantofmayors.eu/about/covenant-community/signatories/overview.html?scity_id=12279
[5] Vida Manzano J, Almagro Pastor JA, García Quesada R. Community response to environmental noise in Granada (Spain): An evaluation by means of a standardized social survey. Proc INTER-NOISE Conf Madrid, Spain. 2019; 259(9):671-682.
[6] Truax B. Handbook for Acoustic Ecology. 2nd ed. Cambridge Street Publishing; 1999.
[7] Radicchi A. Beyond the noise: open source soundscapes. A mixed methodology to analyse, evaluate and plan 'everyday' quiet areas. ASA Proc Meetings Acoust. 2017;30(1):040005.
[8] Kang J, Aletta F, Margaritis E, Yang M. A model for implementing soundscape maps in smart cities. Noise Mapp. 2018;5(1):46–59.
[9] Lionello M, Aletta F, Kang J. A systematic review of prediction models for the experience of urban soundscapes. Appl Acoust. 2020;170(December):107479.
[10] Lex Brown A. A review of progress in soundscapes and an approach to soundscape planning. Int J Acoust Vib. 2012;17(2):73–81.
[11] European Environmental Agency, Good practice guide on quiet areas; 2014.
[12] ISO, ISO 12913 Acoustics - Soundscape Part 1: Definition and conceptual framework; 2014.
[13] Aletta F, Kang J, Axelsson Ö. Soundscape descriptors and a conceptual framework for developing predictive soundscape models. Landsc Urban Plan. 2016;149(February):65–74.
[14] Tarlao C, Steele D, Guastavino C. Investigating factors influencing soundscape evaluations across multiple urban spaces in Montreal. Proc INTER-NOISE Conf Madrid, Spain. 2019; 259(3):6888-6899.
[15] Southworth MF. The sonic environment of cities. MIT Press; 1967.
[16] ISO, ISO 12913 Acoustics - Soundscape Part 2: Data collection and reporting requirements; 2018.
[17] ISO, ISO 12913 Acoustics - Soundscape Part 3: Data analysis; 2019.
[18] Herrera O, Serrano S and Vida Manzano J. Empleo de una encuesta estandarizada para la valoración de la molestia por ruido ambiental. Proyecto piloto en la ciudad de Granada. Proc ICA Conf Madrid, Spain; 2007.
[19] European Parliament. Directive 2002/49/EC of the European Parliament and of the Council of June 2002. Off J Eur Commun. 2002:12–25.
[20] Almagro Pastor JA, Vida Manzano J, García Quesada R. Soundscape approach for noise management of conflict urban areas. The PTS case in Granada (Spain). Proc INTER-NOISE Conf Madrid, Spain. 2019; 259(8):1802-1813.
[21] Vida Manzano J, López Torralbo JM, Almagro Pastor JA, García Quesada R. Noise annoyance mapping in urban environments as an advanced tool for the design of effective noise mitigation actions. Proc INTER-NOISE Conf. Madrid, Spain. 2019; 259(9):659-670.
[22] Aletta F, Margaritis E, Filipan K, Romero VP, Axelsson Ö, Kang J. Characterization of the soundscape in Valley Gardens, Brighton, by a soundwalk prior to an urban design intervention. Proc. Euronoise. 2015;(June):1547–52.
[23] Radicchi A, Henckel D, Memmel M. Citizens as smart, active sensors for a quiet and just city. The case of the 'open source soundscapes' approach to identify, assess and plan 'everyday quiet areas' in cities. Noise Mapp. 2018;5(1):1–20.
[24] Axelsson Ö, Nilsson ME, Berglund B. A principal components model of soundscape perception. J Acoust Soc Am. 2010 Nov;128(5):2836–46.