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Investigating Factors Influencing Soundscape Evaluations Across Multiple Urban Spaces In Montreal

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ABSTRACT

Previous soundscape studies have shown a complex relationship between soundscapes, public space usage and contexts of users' visits to the space. Yet many of these findings are restricted to one study site at a time and may not generalize to a global understanding of urban sound environments. Questionnaire is a common data collection method for soundscape research in indoors and outdoors environments. The present study is a comparative analysis of in-situ questionnaires collected over five study sites in Montreal from 2015 to 2018 (N=1029). At each site, the questionnaire included the Swedish Soundscape Quality Protocol, person-related (e.g. personality) and situation-related (e.g. activity) variables. The analysis reveals an influence of social interaction (alone vs. with others), noise sensitivity, and extraversion, amongst others. For example, people in groups found the soundscape more pleasant and appropriate, and less monotonous and chaotic than people alone. These results have important implications in the design and planning of both indoor and outdoor public spaces, and in particular, the planning of amenities that direct the activities performed in the space. The analysis also identifies methodological implications for improving soundscape questionnaires.

Keywords: Soundscape, Psychological effects, Sociological effects
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1. INTRODUCTION AND REVIEW

The perception and evaluation of the sounds of urban public spaces is dependent on contextual factors, including space, time and activity among others. A body of work on urban soundscape (defined as the "acoustic environment as perceived or experienced and/or understood by a person or people, in context" [1]) has focused on identifying these contextual factors. Within the conceptual framework defined by the ISO, context "includes the interrelationships between person and activity and place, in space and time" [1]. Soundscape research is increasingly interested in these relationships, with emerging theories and models on what influences soundscape evaluations pointing to the users' level of social interaction as a potential moderator of users' perceptions [2]. Specifically, regarding social interaction, studies conducted in different urban spaces from various countries show that socially interactive people found the soundscape more suitable and less disruptive to their activity [3], more appropriate and more pleasant [4], and less unpleasant [5] than solitary respondents. We situate our research within this debate to address questions on the effect of social interaction and site topology on soundscape evaluations using a relatively large dataset.

Soundscape research considers multidisciplinary and mixed methods approaches in characterizing acoustic environments, with an emphasis on measures of human perceptions, rather than physical measurements (e.g. dBA) used in traditional noise control approaches. This also means a shift from sound as a pollutant to using sound as resource [6].

In the last decade, a number of soundscape scales have been developed and refined to measure human perceptions of acoustic environments (see [7] for a methodological review). Axelsson and his team [8] created and validated the Swedish Soundscape Quality Protocol (SSQP), made of eight unidimensional scales, in Swedish and English. With this tool, they found that soundscapes were characterized along three dimensions: *pleasantness*, *eventfulness*, and *familiarity*, with the conclusion that *pleasantness* and *eventfulness* created an orthogonal space. In this space, a calm soundscape would be pleasant and uneventful, and a monotonous soundscape would be unpleasant and uneventful. Our own work has previously validated a French translation of the SSQP [9] in the context of Quebec, with the same first and second dimensions of *pleasantness* and *eventfulness*. Other French translations have been developed in France [10], confirming the same first and second dimensions of *pleasantness* and *eventfulness.* Subsequently, in response to comments, Axelsson [11] recommended adding the assessment of the *appropriateness* of the soundscape to the space as an orthogonal dimension to the *pleasantness* and *eventfulness* dimensions previously established.

This methodological pursuit parallels the increasing number of studies using the soundscape approach, both in-situ and in laboratory settings. However, work in-situ has been traditionally limited to individual locations or investigates one urban morphological type at a time (e.g. parks [12], or public squares [13]). Research on multiple morphological types has been conducted, but these are often lab-based studies [8], or use soundwalks for data collection [7], thus not allowing the investigation of social interaction.

However, this question of social interaction has arisen recently in soundscape research using the questionnaire method. For example, in an experience sampling method (ESM) study, where participants evaluated soundscapes over the course of a week using their cell phones, which sent questionnaires at random times, Steffens et al. [14] found an effect of "company" (i.e. alone, around others, and interacting with others) on pleasantness and eventfulness, such that those who were around others found soundscapes less pleasant than those alone or interacting with others.

Another emerging question of interest in soundscape studies is the potential for restoration [15] of different soundscapes, including urban park soundscapes [16]. Restorative soundscapes enable users to recover from the negative effect of noise exposure, including drained cognitive resources and increased stress levels, and to reflect upon daily or life issues [15]. Restorativeness has been variously operationalized as comprising: fascination, break from routine, and ease of conducting desired activity (e.g. Steele, 2016 [5]).

Beside situational factors, it has been shown that person-related factors can have an influence on auditory perception. For example, noise sensitivity has been shown to be a major factor in explaining reaction to noise and noise annoyance [17]. Ellermeier [17] found a weak, but significant, relationship between loudness ratings and noise sensitivity; there is also a well-documented relationship between noise sensitivity and age (e.g. Schreckenberg et al. [18]). Lastly, there is evidence that the personality factor of extraversion correlates to different soundscape preferences, for example that those who self-report high extraversion rated the soundscapes during shopping and recreation/entertainment activities as more pleasant than low-extraversion peers [14].

In this paper, we present data collected in-situ over five sites, in Montreal, which offers a large questionnaire dataset for meta-analysis. The use of multiple "real-world" sites spread over a relatively small part of a single city reduces the potential for cross-cultural effects. The sites studied were also of different types, allowing us to investigate the differences and similarities, and ultimately the generalizability, between types of urban sites. To this end, we explored the dimensions coming out at each site from the use of the same questionnaire. Finding similar dimensions would allow us to conduct further multi-site analyses to model the influence of context on soundscape judgments, and specifically in this paper, the influence of noise sensitivity and social interaction.

2. METHODS

2.1 Sites

Questionnaires were collected over five study sites in Montreal during summer months from 2015 to 2018 (N = 1029). The sites consisted:

1. **Public Square (PS)**, a small public square on a busy commercial street (962 Mont-Royal street, N = 441),
2. **Pocket Park (PP)**, a pocket park on a busy commercial street (Parc du Portugal, N = 197),
3. **Green Park (GP)**, a medium-sized green park (Parc LaFontaine, N = 41),
4. **Pedestrian Zone (PZ)**, the pedestrianization project of a semi-commercial, semi-residential street (Roy street, N = 103),
5. **Restaurant (RST)**, an indoor restaurant (Restaurant de l'Institut de Tourisme et d'Hôtellerie du Québec, N = 247).

Sites comprised both indoor and outdoor spaces, as well as large and small parks, and public and private spaces. Sites were not chosen using a sampling strategy. Rather, each site was part of an original study by the authors and all data has been compiled in the format of a meta-study. All conditions internal to the specific studies have been collapsed.

2.2 Questionnaires

The questionnaire was offered in French or English (fully in one language or the other), as preferred by each respondent. Common questions (see Table 1) between all sites in the questionnaire were soundscape-related (Sound sources heard, Swedish

Soundscape Quality Protocol [SSQP], Appropriateness, Loudness, Restorativeness), personality- and person-related (Extraversion, Noise Sensitivity, Age, Gender), and situation-related (Activity conducted, Social Interaction). This paper focuses on the analysis of numerical and binary variables, excluding Gender, which showed no differences between sites.

Note that the Restorativeness question was not on the questionnaires for the RST site for lack of contextual relevance for diners. Additionally, as the data collected in the Parc du Portugal (PP) and Parc LaFontaine (GP) was rated on 7-point Likert scales, we scaled down and rounded each individual rating to a 5-point scale for those two sites.

Table 1. Variables in common between the five sites' questionnaires

Section	Variable	Type
Soundscape	Sound sources (Pleasant, Unpleasant, Neutral)	Free response
	Pleasantness	Likert scale
	Monotony	Likert scale
	Vibrancy	Likert scale
	Chaoticness	Likert scale
	Calmness	Likert scale
	Eventfulness	Likert scale
	Appropriateness	Likert scale
	Loudness	Likert scale
	Restorativeness	Likert scale
Personality/Person	Extraversion	Likert scale
	Noise Sensitivity	Likert scale
	Age	Free response
	Gender	Binary
Situation	Activity	Free response
	Social Interaction (alone or in a group)	Binary

2.3 Respondents

Of the 1029 respondents, 76% chose to fill the questionnaire in French, and 24% in English. They were 53% women, and 44% men, with an average age of 38.9 ± 16.6. Note that the RST site showed significant differences in participants' profiles (see Table 2), with increased Age and Noise Sensitivity.

Table 2. Respondents' profile by site (PS = Public Square, PP = Pocket Park, GP = Green Park, PZ = Pedestrian Zone, RST = Restaurant)

	PS		PP		GP		PZ		RST	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	35.3	.73	32.9	.87	37.3	2.3	33.5	1.4	52.7	1.1
Extraversion	3.51	.05	3.43	.09	3.43	.20	3.38	.11	3.57	.07
Noise Sensitivity	3.11	.07	2.51	.09	2.71	.19	3.20	.13	3.94	.07

2.4 Statistical analysis

We conducted Principal Component Analyses (PCA), MAN(C)OVAs, and mediation analysis in IBM® SPSS® 24.

The PCA were conducted on the nine items pertaining to sound (SSQP, Appropriateness, Loudness, Restorativeness), with oblique rotation (direct oblimin), for each site (a varimax rotation gave similar results for all PCA). The Kaiser–Meyer–Olkin measures verified the sampling adequacy for all analyses but the one on site GP (N = 41, KMO = .49), with values from .69 to .77 ("middling" according to [19, p. 225]), and all

KMO values for individual items were, for the most part, far greater than .5, which is the acceptable limit (except for site GP, which has three "unacceptable" KMO values under .5, and site PZ, which had two).

Another PCA with the same parameters was run over all the data collapsed. The overall KMO measure reached a value of .77, and individual KMO values were all above .58. We replaced the missing values by the mean, as there was less than 6.0% (0.6-5.9%) missing values per variable tested.

To investigate the effect of contextual and person-related factors on the soundscape ratings for each site, we conducted a MANCOVA over all sound-related variables with Social Interaction and Site as the independent variables, and Noise Sensitivity and Extraversion as covariates.

We also wanted to conduct an exploratory analysis of the relationships between our soundscape variables, looking at the paths of influence of the site on the pleasantness rating. We hypothesized that the influence of Site on Pleasantness would be mediated by the participants' perceptions of the sound environment. In light of the concerns with the causal steps approach, we used Hayes' [20] approach to *conditional process analysis* to explore the influence of Site on soundscape Pleasantness, as mediated by the soundscape judgments (excluding Restorativeness so as to keep all cases). We conducted a simple mediation analysis with multicategorical antecedent, using ordinary least squares path analysis in Hayes's PROCESS macro [20].

3. RESULTS

The results are structured in 3 parts: the soundscape dimensions informed by a dimensional analysis of ratings taken across all questionnaires; the analysis of the influence of Social Interaction on soundscape judgments; and a model of the prediction of the soundscape Pleasantness by site and soundscape judgments.

3.1 Dimensional analysis of soundscape ratings

All of the numerical sound-related ratings collected were compared for uniqueness. That is, we tested for similarity of meaning assigned by respondents to the different scales, and their associations depending on the context. For example, the soundscape scales Monotonous and Calm can overlap depending on the setting. This could mean a different understanding of the scales and their overlap across the different Sites we studied. Principal Component Analyses, for each site and over all the data, address this question across all collected ratings.

Table 3. Total variance explained for each PCA per site

Site	Sample size	# factors	Total Variance Explained (%)
PS	441	3	63.7
PP	197	4	71.4
GP	41	4	74.8
PZ	103	3	67.3
RST	247	3	68.6

The individual Principal Component Analyses showed similar results across sites, which were confirmed in an overall PCA. In each PCA, the total variance explained ranged from 63.7 to 74.8% (see Table 3). The 5-sites PCA on sound-related variables yielded similar components. Based on the scree plots, we retained three factors for three sites (PS, PZ, RST) and four factors for the other two sites (PP, GP). The items that cluster on the same factor suggest that: factor 1 represents what we labeled as soundscape

appreciation, which always includes (but is not limited to) what we might consider "positive" aspects, i.e. pleasantness, appropriateness, and restorativeness (25.1-38.5%); factor 2 – soundscape *dynamism*, including eventfulness and vibrancy (17.2-22.2%); factor 3 – soundscape *monotony*, usually including only monotony (10.5-14.1%). *Loudness*, while usually part of factor 1, becomes a standalone, fourth, factor for PP and GP (alone in PP, 8.1%; and including calmness in GP, 12.0%).

For the overall PCA, the scree plot was ambiguous and showed inflexions that would justify retaining either three or four factors. We retained three factors because of the large sample size and the convergence of the scree plot and Kaiser's criterion on this value. The retained factors explain 63.4% of the variance. Similar to the individual PCAs, the items that cluster on the same factors (see Table 4 for factors loading) suggest that factor 1 represents the soundscape's *appreciation* (33.3%), factor 2 represents *dynamism* (18.9%), and factor 3 *monotony* (11.3%).

Table 4. Factors loading of overall PCA (N = 1029)

	Rotated Factor Loadings		
Item	Appreciation	Dynamism	Monotony
Calm	**.807**	-.154	.145
Pleasant	**.786**	.220	-.096
Appropriate	**.721**	.158	.018
Restorative	**.624**	.159	.036
Loudness	**-.586**	.340	.134
Eventful	.026	**.854**	-.013
Vibrant	.137	**.811**	-.097
Monotonous	.135	-.141	**.942**
Chaotic	**-.469**	.218	**.474**
Eigenvalues	2.994	1.696	1.016
Variance explained (%)	33.3	18.9	11.3
Cronbach α	.79	.70	.50

In summary, the findings demonstrate that the same factors underline soundscape evaluations in the different sites, suggesting that respondents assigned similar meanings to the scales across different settings (including outdoor v. indoor settings). Additionally, the first two dimensions emerging from our data are in line with the literature, i.e. one focused more on affect / a value judgment of soundscapes – what we labeled as *appreciation*, and one focused on its *dynamism*. However, departing from the literature, *monotony* emerges as its own, third, factor. Finally, we showed that eventfulness and vibrancy are closely related and isolated from the other scales; their high association could indicate that they measure the same judgments.

3.2 Contextual and person-related factors

This section covers the investigation of the influence of the contextual variables of Social interaction and Site, and of the person-related variables of Noise Sensitivity and Extraversion, on the sound-related variables. Regarding Social Interaction, we collapsed responses to only two possibilities across all participants: alone or with others. Because of the similarity between the dimensions results from the PCA, we concluded that performing site analyses collapsed across sites was pertinent.

To compare the effects of ordinal and nominal variables, we conducted a MANCOVA with Social Interaction and Site as nominal (categorical) predictors, and Noise Sensitivity and Extraversion as ordinal (scale) covariates. However, we excluded

two sites of this analysis: the RST site, which, by its very nature as a restaurant, contains too few solitary respondents (N = 12 compared to N = 235 for socially-interactive respondents); and the GP site, for which the small sample size (N = 41), compounded with what qualitatively appears to be a social nature, also yields too few solitary respondents (N = 9). Note that excluding the data from the RST site allowed us to keep the Restorative variable in the analyses.

Therefore, we conducted a MANCOVA on the three sites of PS, PP, and PZ (N = 737). We ran the analysis with Social Interaction and Site as categorical predictors, and Noise Sensitivity and Extraversion as covariates, on all sound-related variables. We found a main effect of Social Interaction ($F(9,721) = 2.155$, $p = .023$), Site ($F(18,1444) < .001$), but no significant interaction between the two ($p = .186$). The covariates also had a significant effect (Sensitivity: $F(9,721) = 5.179$, $p < .001$; and Extraversion: $F(9,721) = 2.357$, $p = .013$).

Table 5. Significant between-subject tests for the Multivariate Analysis of Covariance. Estimates of effect for Social Interaction are measured as (interactive - solitary). Estimates for Noise Sensitivity and Extraversion are measured as the slope of the regression as the covariate increases. A positive score for "estimate" means that the direction of the relationship is positive for that variable (e.g. pleasantness rises for interactive respondents and decreases with noise sensitivity). Estimates for Site are not shown here for ease of lecture (see Figure 1).

IV / covariate	DV	Estimate	F	df	Error df	*p*	Partial η^2
Social Interaction	Pleasant	.488	6.20	1	729	.013	.008
	Appropriate	.431	9.22	1	729	.002	.012
	Chaotic	-.459	11.13	1	729	.001	.015
	Calm	.761	7.25	1	729	.007	.010
	Loud	-.322	4.76	1	729	.029	.006
Site	Pleasant	-	19.15	2	729	< .001	.050
	Appropriate	-	7.65	2	729	.001	.021
	Monotonous	-	21.06	2	729	< .001	.055
	Chaotic	-	17.82	2	729	< .001	.047
	Calm	-	10.55	2	729	< .001	.028
	Restorative	-	4.30	2	729	.014	.012
	Loud	-	37.02	2	729	< .001	.092
Noise Sensitivity	Pleasant	-.066	5.71	1	729	.017	.008
	Monotonous	-.120	14.47	1	729	< .001	.019
	Calm	-.092	7.51	1	729	.006	.010
	Restorative	-.084	7.29	1	729	.007	.010
	Loud	.130	22.35	1	729	< .001	.030
Extraversion	Pleasant	.066	4.37	1	729	.037	.006
	Eventful	.100	7.60	1	729	.006	.010

As Table 5 shows, the more Extraverted the respondents are, the more Pleasant and Eventful they find the soundscape. Additionally, an increase in Noise Sensitivity means a soundscape perceived as less Pleasant, less Appropriate, less Monotonous, less Calm, less Restorative, more Chaotic, and Louder. The soundscapes of the different Sites were also perceived differently (see Figure 1).

Additionally, the lack of interaction between Site and Social Interaction shows that we can consider the significant differences found with Social Interaction independently from an effect of the site. Those differences are as follows: people in groups find the soundscape more Pleasant, more Appropriate, Calmer, less Chaotic, and less Loud than people on their own, across all sites.

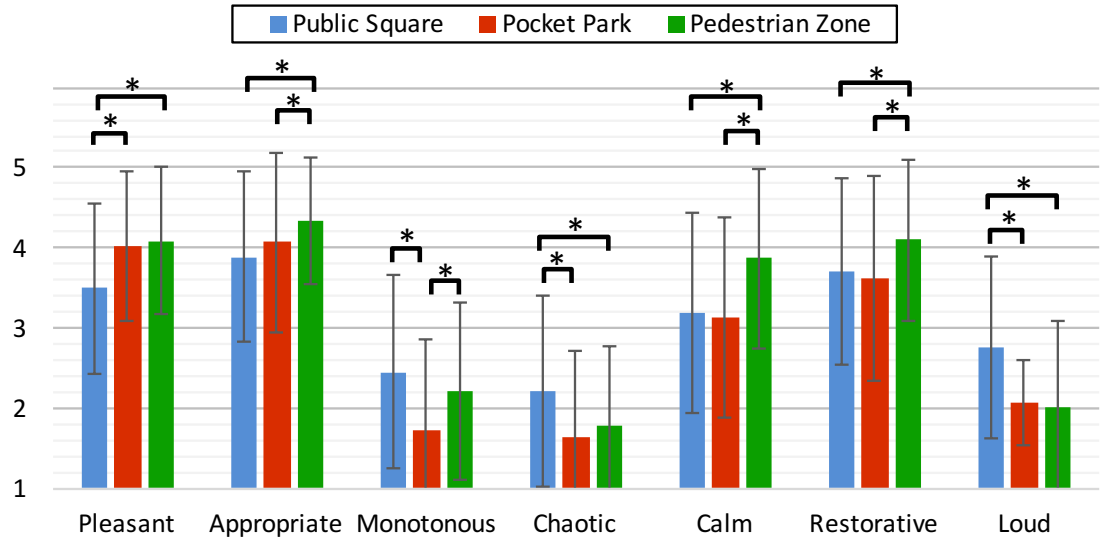

Figure 1. Soundscapes judgments that are significantly different between Sites. Errors bars show standard deviations. Stars denote significant differences at α = .05.

3.3 Predicting Pleasantness

As Pleasantness is one of the most common scales used in soundscape research, we investigated how Pleasantness can be predicted by individual sites' soundscape ratings. We tested a model accounting for a direct effect of the space on how pleasant the space's soundscape is perceived, as well as the effect of the other soundscape variables tested – as they are themselves influenced by the space, and as they influence the perception of Pleasantness. This analysis was, in part, justified by the PCA showing close associations of a number of variables with Pleasantness on the *appreciation* dimension (see section 3.1).

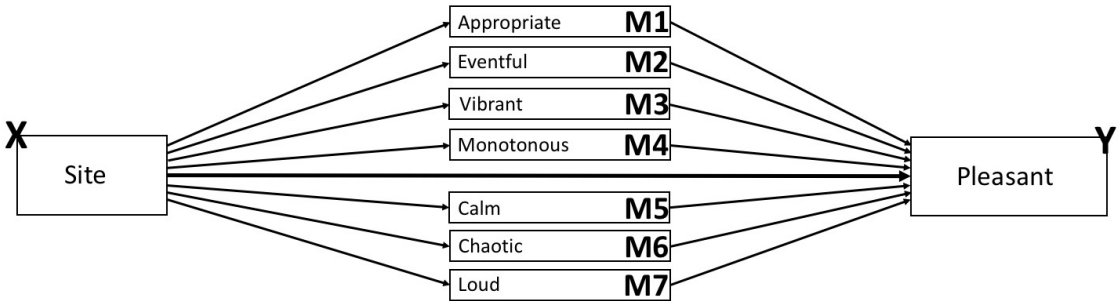

Figure 2. Model of the effect of Site on Pleasantness through the soundscape ratings. Solid arrows denote significant influences with a p < .05 (see Table 5 for details).

We conducted a simple mediation analysis with a multicategorical antecedent (see Figure 2 for model). The results show a site's soundscape is deemed more pleasant when it is judged as more appropriate, more eventful, more vibrant, less monotonous, calmer, less chaotic, and less loud. We found that the site directly and indirectly influences the perception of pleasantness through all of the other soundscape judgments included (see Table 6). For example, the soundscape in PP was perceived as more pleasant than in PS, because it is judged as more appropriate, and a more appropriate soundscape is found more pleasant. The relative indirect effect of site PP relative to site PS on the perceived pleasantness of the soundscape via its appropriateness is .255(.355) = .091 (see Table 6); that is, the soundscape in PP was perceived as more pleasant than in PS by .091 units, because it was judged as .255 units more appropriate, and a soundscape more appropriate by 1 unit is found more pleasant by .355 units.

Table 6. Regression coefficients and model summary information for the mediation analysis. X1 represents the comparison of PP to PS, X2 represents the comparison of GP to PS, X3 represents the comparison of PZ to PS, X4 represents the comparison of RST to PS.

	Consequent																	
	Pleasant (total)		Appropriate		Eventful		Vibrant		Monotonous		Calm		Chaotic		Loud		Pleasant	
Antecedent	Coeff	*p*	Coeff	*p*	Coeff	*p*	Coeff	*p*	Coeff	*p*	Coeff	*p*	Coeff	*p*	Coeff	*p*	Coeff	*p*
X1	.557	.000	.255	.003	.188	.047	.145	.112	-.680	.000	.127	.211	-.658	.000	-.729	.000	.220	.000
X2	.887	.000	.450	.006	.530	.003	.382	.027	-.896	.000	.524	.007	-.888	.000	-.884	.000	.274	.016
X3	.579	.000	.439	.000	.048	.693	.228	.049	-.240	.047	.679	.000	-.428	.000	-.721	.000	.088	.245
X4	.487	.000	.068	.393	.172	.050	.178	.035	-.586	.000	.185	.049	-.848	.000	.274	.000	.298	.000
Appropriate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.355	.000
Eventful	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.088	.000
Vibrant	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.116	.000
Monotonous	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	-.039	.050
Calm	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.243	.000
Chaotic	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	-.110	.000
Loud	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	-.115	.000
Constant	3.510	.000	3.891	.000	3.021	.000	3.098	.000	2.457	.000	3.194	.000	2.226	.000	2.751	.000	1.385	.000
	R^2 = .081 F(4,1024) = 22.636, *p* = .000		R^2 = .024 F(4,1024) = 6.394, *p* = .000		R^2 = .012 F(4,1024) = 3.010, *p* = .015		R^2 = .010 F(4,1024) = 2.491, *p* = .042		R^2 = .076 F(4,1024) = 21.091, *p* = .000		R^2 = .030 F(4,1024) = 8.025, *p* = .000		R^2 = .121 F(4,1024) = 35.275, *p* = .000		R^2 = .164 F(4,1024) = 50.243, *p* = .000		R^2 = .552 F(11,1017) = 113.688, *p* = .000	

In summary, the soundscape is judged as more pleasant (by 1 unit) when it is perceived as more appropriate (by .355 unit), more eventful (.088), more vibrant (.116), calmer (.243), less monotonous (.039), less chaotic (.110), and less loud (.115).

In comparison to PS, the soundscape in PP is perceived as more pleasant (by .557 unit), more appropriate (.255), more eventful (.188), less monotonous (.680), less chaotic (.658), and less loud (.729).

In comparison to PS, the soundscape in GP is perceived as more pleasant (.887), more appropriate (.450), more eventful (.530), more vibrant (.382), calmer (.524), less monotonous (.896), less chaotic (.888), and less loud (.884).

In comparison to PS, the soundscape in PZ is perceived as more pleasant (.579), more appropriate (.439), more vibrant (.228), calmer (.679), less monotonous (.240), less chaotic (.428), and less loud (.721).

In comparison to PS, the soundscape in RST is perceived as more pleasant (.487), more eventful (.172), more vibrant (.178), calmer (.185), less monotonous (.586), less chaotic (.848), and less loud (.274).

4. DISCUSSION AND CONCLUSIONS

The use of our questionnaire data collection instrument since 2015 has provided the opportunity to analyze and evolve the instrument to be useful and time-effective for on-site studies. Using only minor modifications of the scales, we were able to present this meta-analysis using over 1000 questionnaires to provide insight on some of the contextual factors influencing soundscape evaluation, and even some of the interactions between descriptors themselves.

Respondents across sites, including indoor and outdoor settings, assigned similar meaning to the same scales (see section 3.1), thus we expect that a standardized soundscape questionnaire is portable to multiple environments. This finding should support efforts such as the development of an ISO standard for conducting soundscape preference assessments (detailed in Brown et al., 2011 [21]), and may even support extending the use of a standard questionnaire beyond only outdoor environments. Soundscapes were evaluated along dimensions that we labeled *appreciation* (including notions of soundscape pleasantness and appropriateness)*, dynamism* (eventfulness and vibrancy), and *monotony*.

Those results call into question what the literature says about the independence (orthogonality; i.e. measuring distinct concepts) of the descriptors *monotonous* and *calm*, as well as their "diagonality" with the *pleasantness* and *eventfulness* dimensions (wherein a monotonous soundscape is unpleasant and uneventful, while a calm soundscape is pleasant and uneventful – see Axelsson [8]). Given our large sample size and data in two languages, we have the opportunity to situate this dataset among others. In our findings, the first two dimensions emerging from the data are similar to those proposed by Axelsson [8], i.e. one focused more on affect / a value judgment of soundscapes – what we labeled as *appreciation* (similar to Axelsson's *pleasantness*) and one focused on its *dynamism* (*eventfulness* for Axelsson). However, Axelsson had described monotonous and calm as orthogonal descriptors in Swedish/English. Departing from Axelsson, we show that calmness and monotony are not orthogonal from each other nor diagonal on our appreciation-dynamism two-dimensional space. In our research, calmness is associated with the appreciation factor, while monotony is its own factor, indicating that the meaning assigned to these scales differs from the one proposed by Axelsson. Another French language study, by Jeon et al. [10], also found these descriptors to be co-rated; however, they also found monotonous ("ennuyeux") to not have its own dimension as we did. Rather, they found monotonous to be treated very similarly to unpleasant. We suggest

that *monotonous* is actually the third most important descriptor in explaining a soundscape evaluation.

Other laboratory-based studies had found this third variable to be *familiarity* [14], a descriptor we did not measure directly, but rather, we estimated the respondents familiarity with the space. In an attempt to disambiguate the familiarity that a lab-based participant might interpret as "how representative is this soundscape?", we measured familiarity by asking how often they visit the space, and whether they live nearby We hope to reconcile this question between our sites and consider it in future analyses, especially in relation to the activities performed in the soundscape. Axelsson [11] had also recommended adding the assessment of the *appropriateness* of the soundscape to the space as an orthogonal (independent) dimension to the *pleasantness* and *eventfulness* dimensions previously established. However, *appropriateness* emerged from our data on a shared dimension with *pleasantness*, indicating a high level of association between the two. Lastly, we showed that eventfulness and vibrancy are closely related and isolated from the other scales, indicating a similar "lack of diagonality" between them, as opposed to Axelsson's findings (wherein a vibrant soundscape is pleasant and eventful); their high association could indicate that they in fact measure the same judgments.

Across all sites tested, people engaging in social activities are more satisfied with their soundscape than people on their own, both with an increase in positive perceptions (pleasant, appropriate, calm), and a decrease of negative perceptions (chaotic, loud). Steffens et al. [14], similarly found that those who were interacting with others rated soundscapes as more pleasant; however, their study did not control for site. They had found higher pleasantness ratings for those who were alone and not around others than for those who were alone while around others – the presence of the (presumably pleasant) home environment likely weakened the strength of their finding. Situated with our results here, we found a consistent trend of higher pleasantness around others, but showed the extent to which that can vary even in different public spaces.

As may be expected, a soundscape is deemed more pleasant when it is judged as more appropriate, more eventful, more vibrant, less monotonous, calmer, less chaotic, and less loud. We modeled how the Pleasantness dimension of the soundscape is influenced by data collection site through the effect of the other soundscape ratings because Pleasantness is the most commonly used descriptor of sound environments. However, as the literature and the evidence suggest, Appropriateness might be just as, if not more in certain circumstances, relevant and informative. We therefore want to explore that option further in the future. We also want to look more closely at moderation by Noise Sensitivity and Social Interaction, as hinted by the MANCOVA presented in section 3.2. Note that this analysis of variance presented a number of problems (violation of the assumptions of normality, univariate and multivariate outliers, and homogenous covariance matrix, independence of all predictors and covariates). We also had to exclude two of our sites because of highly unequal sample sizes. Nevertheless, we invoked the test to illustrate the potential of this Social Interaction variable to lend predictive power to soundscape evaluations. And we hope to refine this analysis with appropriate data transformations and/or non-parametric tests in future steps.

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