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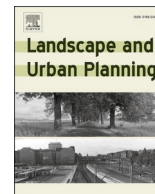
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Shaping city soundscapes: In situ comparison of four sound installations in an urban public space

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H I G H L I G H T S

- 4 sound installations were evaluated in-situ (825 questionnaires over 2 years).
- All 4 installations enhanced soundscape evaluations overall.
- Different benefits were observed for each installation in the same space.
- The benefits were related to external factors including nearby construction noise.
- Three installations distracted participants from other non-dominant sound sources.

A B S T R A C T

The soundscape approach considers sound as a resource from a user perspective in the planning of public spaces. While this approach is garnering increased research attention, practitioners rarely integrate sound into their practice beyond noise mitigation. Yet, sound design of public spaces has long been a major focus of sound installation artists, who offer creative site-specific interventions to (re)design public spaces. In this study, we present the systematic evaluation and comparison of four temporary sound installations deployed over two consecutive summers in the same urban public space. The sound installations featured compositions by the artist collective Audiotopie using different combinations of ambient music, nature, and vocal sounds. To measure the effects of the sound installations on users' experience, we deployed 825 questionnaires including soundscape ratings and sound source listings. The results show that all four sound installations improved the public space's soundscape, with commonalities (increased *calmness* and *pleasantness*, decreased perceived loudness) and specificities (increased sense of *being-away* for one installation, increased *extent-coherence* and reduced ratings for *chaotic* for another) related to compositional and contextual factors, such as the intended design goals, users' location, or the presence of construction noise. As well, three of the four installations distracted participants from other non-dominant sound sources such as construction works, air conditioners, but also birds and human voices. Overall, the results confirm that sound installations can have a common enhancing effect on the experience of public space users, in addition to specific, tailored effects to reinforce the intended design goals in public spaces.

1. Introduction

Artistic expression through sound has always been part of urban life, for example in the form of street music, or more recently with the emergence of sound installation art (LaBelle, 2006). These forms of expression remind us that urban sound environments are not just a byproduct of the functionalist imperatives of cities, but are actively shaped by their inhabitants, and that sound artists can play a role in the design of city sounds (Lacey, 2016). Indeed, sounds shape our perception of cities with both positive and negative consequences (Kang & Schulte-Fortkamp, 2015). As such, sound can be integrated as a resource

in urban planning in a user-centered perspective through the soundscape approach (Brown & Muhar, 2004). If such considerations are gaining interest in the soundscape research field, sound remains typically framed as a public health issue by urban planners. Notably, there are few documented cases and established guidelines for user-centered approaches to manage sound (Steele et al., 2023), and the adoption of such approaches by practitioners remains a major challenge for soundscape research (Aletta & Xiao, 2018).

To address this research-practice gap, the study of soundscape interventions has become increasingly popular among soundscape researchers in the recent years (Fiebig & Schulte-Fortkamp, 2023).

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Although the term is currently debated, a soundscape intervention is understood here as “a site-specific design, aimed at preserving or improving an acoustic environment” (Moshona et al., 2024, p. 10). Soundscape interventions can take many forms since they imply a holistic approach for (re)designing spaces with sound in mind. Two fundamental approaches usually guide the design of soundscape interventions: reducing unwanted sounds, and introducing or reinforcing wanted sounds (see Brown & Muhar, 2004; Cerwén et al., 2017; Hong & Chong, 2023). These approaches can be considered separately or jointly in relation to site-specific criteria, such as the existing sound environment, its functions, and desired activities. The reduction of unwanted sounds typically involves standard noise mitigation techniques (e.g. noise barriers, reducing traffic speed), whereas the introduction or reinforcement of wanted sounds usually relies on either introducing natural sounds (e.g. fountains, vegetation), encouraging human interactions by attracting desired activities, adding music through loudspeakers, or deploying sound installations (see Cerwén et al., 2017 for detailed examples).

These approaches are complementary and should be considered in conjunction whenever possible (Hong & Chong, 2023). Nonetheless, studies have shown that the introduction of wanted sounds alone can benefit urban public spaces. For instance, in situ studies have shown that added sounds in public spaces can positively affect people’s behavior, such as fostering social interactions (e.g. Bild et al., 2016; Chen & Kang, 2023) or promoting activities such as chatting or eating (e.g., Aletta et al., 2016), while other studies have reported improvements in soundscape evaluations through global assessments (e.g., Cerwén, 2016; De Pessemier et al., 2022) or increases in *eventfulness* (e.g., Jambrošić et al., 2013), or *pleasantness* (e.g., Steele et al., 2021) ratings. In laboratory settings, the benefits of adding natural sounds have been extensively studied, with studies showing their influence on psychological restoration (e.g., Hsieh et al., 2023; Zhang & Chen, 2023) or positive effects on soundscape ratings in noisy environments (e.g. Lugten et al., 2018; Hong et al., 2020; Puyana-Romero et al., 2021). In addition, two recent laboratory studies have looked at the effects of sound installations on variables such as *appropriateness*, *pleasantness* and *familiarity* (see Oberman et al., 2020; Fraisse et al., in press). If such studies showed that adding pleasant sounds to public spaces can enhance user experience, research on the introduction of curated content such as sound installations remains sparse (see Fraisse et al., in press for a review).

In this paper, we focus on sound installations as a specific kind of soundscape intervention in public spaces. Sound installations are closely related to sound art in that any sound can be considered as a potential aesthetic material as part of their creation (LaBelle, 2006). Sound installations have a distinctive relation to their deployment site, such that they can be defined as “places, which have been articulated spatially with sounding elements” (Bandt, 2006, p.353). Despite the sparsity of soundscape studies on sound installations, sound artists have always carefully considered the relationship between their work, the listening situation they induce, and the site in which it is embedded. The creative process involved when designing a public space sound installation involves a bottom-up approach, where site-specific criteria are accounted for, including not only physical parameters but also historic and socio-cultural aspects (Tittel, 2009). Through the development of this unique expertise, sound artists can propose tailored solutions to (re) design existing urban spaces, thus providing city planners with novel solutions for public space sound design (Cobussen, 2023). Specifically, temporary sound installations can increase city users’ awareness of the sound environment and its possibilities, fostering discussions and engagement to improve the urban environment, laying the groundwork for longer-term interventions, in an iterative process (Brown & Muhar, 2004). We suggest that temporary sound installations, as a form of low-cost, short-scale, ephemeral interventions, could be added to the tactical urbanism toolkit towards the development and improvement of public spaces (Lydon & Garcia, 2015; Di Croce & Guastavino, 2024).

To do so, it is necessary to be able to document the potential effect of

sound installations on public spaces. To the best of our knowledge, there is no field study involving the systematic comparison of multiple sound installations in the same space to assess the relationship between different compositions and their effect on soundscape. In short, current research does not provide enough evidence to develop precise hypotheses about the effect of sound installations on soundscape assessment. As a result, sound installations remains marginal, if not obscure for many urban planners. To start addressing these issues, this study systematically assesses the effects of four sound installations in the same public space.

Another major challenge in the soundscape field resides in the lack of clarity regarding the way the soundscape approach should be applied (Aletta & Xiao, 2018), especially to help soundscape non-experts like artists and planners. Specifically, there is no existing consensus on a protocol for soundscape measurement, despite recent efforts for its standardization by the International Organization for Standardization (ISO TS 12913-1, 2014; ISO TS 12913-3, 2019; ISO TS 12913-2, 2018). Likert scales have been the most widely spread tools for soundscape evaluation, including the Swedish Soundscape Quality Protocol, presented in the ISO TS 12913-2:2018 in the form of a two-dimensional 8-scales set (*pleasantfulness* and *eventfulness*), while the standard also proposed a scale for *appropriateness* (ISO TS 12913-2, 2018). The Perceived Restorativeness Soundscape Scales (PRSS), derived from the Attention Restoration Theory, is also commonly used to measure the restorative potential of soundscapes (Payne & Guastavino, 2018). More qualitative, open-ended methods for soundscape evaluation are also widespread, such as collecting sound source listings or guided interviews (ISO TS 12913-2, 2018). The combination of different methods (i.e. methodological triangulation) is recommended to increase measurement validity (ISO TS 12913-3, 2019). In light of the current efforts to establish standardized guidelines to implement soundscape interventions (ISO/AWI TS 12913-4, 2023), the present study seeks to assess different measurement protocols to evaluate interventions.

The present work is conducted in the context of the Sounds in the City project, a cross-sector partnership between researchers, the city of Montreal, and private partners to produce knowledge about urban soundscapes, offering unprecedented experimental design opportunities. This paper focuses on documenting and comparing the soundscape effects of four temporary sound installations in the same public space, the Fleurs-de-Macadam square in Montreal. The project was part of a broader public space project initiated by the Plateau-Mont-Royal borough of the City of Montreal to turn a vacant lot into a new public square. Through consultations with local residents, workers, business owners and community organizations, the City of Montreal identified different purposes for this new public space. The design firm Castor et Pollux was subsequently hired to design and implement three temporary design prototypes in 2018 and 2019. For each design, sound artists from the collective Audiotopie were invited to develop sound installations meant to “resonate” with the intended ambiances. This was a unique opportunity to experiment with sound installations as a means to shape the soundscape of the square, reinforce the purpose of the temporary designs, and enhance the experiences of public space users.

Separate soundscape effects of the installations on soundscape ratings were partially reported in (Fraisse et al., 2020; Steele et al., 2019; Fraisse, 2019), while a description of the research-creation collaboration is available in (Guastavino et al., 2022). We focus here on the systematic evaluation and comparison of the soundscape effects of the four installations. One of the study goals is to investigate three research hypotheses based on previous research. First, we seek to assess the relation between the nature of added sounds (specifically, whether sounds are identifiable or not—that is, referential or abstract), and their propensity to be more noticeable (see Fraisse et al., in press). Second, we want to better understand how added sounds might distract listeners’ attention from other sources through attentional or non-energetic masking (see Fraisse et al., in press for a review). Finally, we seek to investigate whether natural sounds have a stronger restorative potential than other

types of added sounds (see, for instance, Alvarsson et al., 2010; Hsieh et al., 2023). We also expect to capture soundscape effects that had not been previously observed, as there are currently very few studies, much less systematic or field-based, that examine the soundscape effects of sound installations. In summary, the present work seeks to assess the potential benefits of temporary sound installations in relation to the composition strategies, in order to better understand how sound installations can be used and integrated in urban projects.

2. Method

2.1. Public space Designs

Initially a vacant lot, the Fleurs-de-Macadam square underwent three prototype designs (see Fig. 1 and Fig. 2) in the summers of 2018 (Designs A and B) and 2019 (Design C). The lot is located in the Plateau-Mont-Royal borough, a former working-class district, densely built-up area, now gentrified and popular with tourists and residents alike. It is along a relatively narrow avenue (Mont-Royal) bordered by contiguous buildings, most of which house commercial activities at street level and apartments on the upper levels (plexes). The public space was completely rearranged for each prototype with different layouts and amenities, tailored to the intended purposes (identified through public consultation) by design firm Castor et Pollux. Design A was designed for relaxation, with a quiet side with benches (lower half of the space on Fig. 1) and a more active side with meeting tables (upper half of the space). Design B was intended to foster Culture and social interactions and included a stage and seating elements. Designs A and B were deployed for 2 months each, while Design C, targeted for mixed use, was deployed all summer 2019 and combined the most popular features from the summer 2018, with meeting tables, a central platform, and quieter zones with benches. Unexpectedly, construction on an adjacent street restricted traffic (and its noise) around the space in summer 2019 and added construction noise during Design C (see Fig. 3).

2.2. Sound installations

Four sound installations were developed by the artist collective Audiotopie to resonate with the purposes of the different designs. Each installation was deployed for a portion of the full design duration (roughly two to three weeks out of six, see Fig. 3). Throughout their deployment periods (colored boxes in Fig. 3), the sound installations were on during the day from 9am to 11 pm. The temporal evolution was controlled through independent loops of different durations presented

alternatively on the different speakers. The introduced content included intermittent periods of silence and relied on different spatial and temporal evolutions, all of which is described in further detail in (Guastavino et al., 2022). In this article, installations will be described in terms of abstract and referential sonic material they contain and positioned along an oppositional/integrated continuum (see Landy, 2007; Livingston, 2016).

In 2018, two separate four-speaker installations were deployed with different spatial layouts for Designs A and B (see Fig. 3). In the first sound installation – Woodlands – speakers were positioned into an L-shaped layout on the half closest to the residential area, between the platform and the pedestrian path abutting houses, referred to as “the lower half” in this paper in relation to the map (see Fig. 1). The installation was designed to reinforce the sense of tranquility and foster restorativeness. Composer Lou Duchemin-Lenquette relied on an integrated compositional strategy, with referential sounds evoking nature (bird chirps, insects and wooden blocks) and subtle impulsive electronic sounds distributed through space (see Audio 1). Because of spatial layout and the integrated nature of the composition, the sound installation was much more audible in the lower half of the space than on the upper side (see highlighted area in Fig. 1). For the second sound installation – Voices – speakers were positioned in a space around a seating area (Fig. 1). Composer Étienne Legast relied on a mostly oppositional compositional strategy based on speech sounds. In the foreground, words and short sentences were spoken successively by a woman and a man at varying rates. The background included short musical excerpts and urban sound elements (see Audio 2).

Audio 1: excerpt of the Woodland sound installation. Courtesy of Audiotopie.

Audio 2: excerpt of the Voices sound installation. Courtesy of Audiotopie.

Composed by Simone D’Ambrosio, the third and fourth sound installations – Synthesizers and Seascape, respectively – were in place for two week each in the summer 2019 over Design C, both using the same configuration of eight speakers along the diagonal of the space (see Fig. 1 and Fig. 3). The Synthesizers installation relied on an oppositional composition strategy and was exclusively made from synthesized, abstract sounds such as arpeggiated chords, harmonic beatings and rasterized percussive patterns (see Audio 3). Conversely, the Seascape installation used an integrated strategy with a majority of referential sounds evoking natural elements and especially the sea (e.g. sea waves, ships, but also stream sounds, rain and forest wind) as well as a few and more abstract ambient pads (see Audio 4).

Audio 3: excerpt of the Synthesizers sound installation. Courtesy of



Fig. 1. Map of the studied site, showing each of the design layouts (Design A and B: 2018; Design C: 2019), as well as measurements and speaker positions. Maps for designs A and B provided by design firm Castor et Pollux and used and edited with permission.

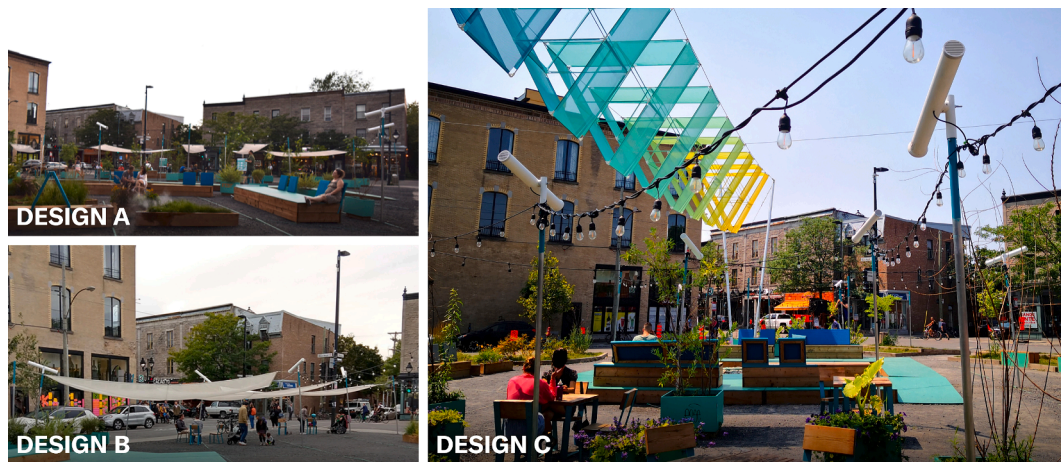


Fig. 2. Photographs of each space design with sound installations. Speakers are enclosed in white cylindrical boxes attached on poles. Pictures: Audiotope for Designs A and B; Valérien Fraisse for Design C.

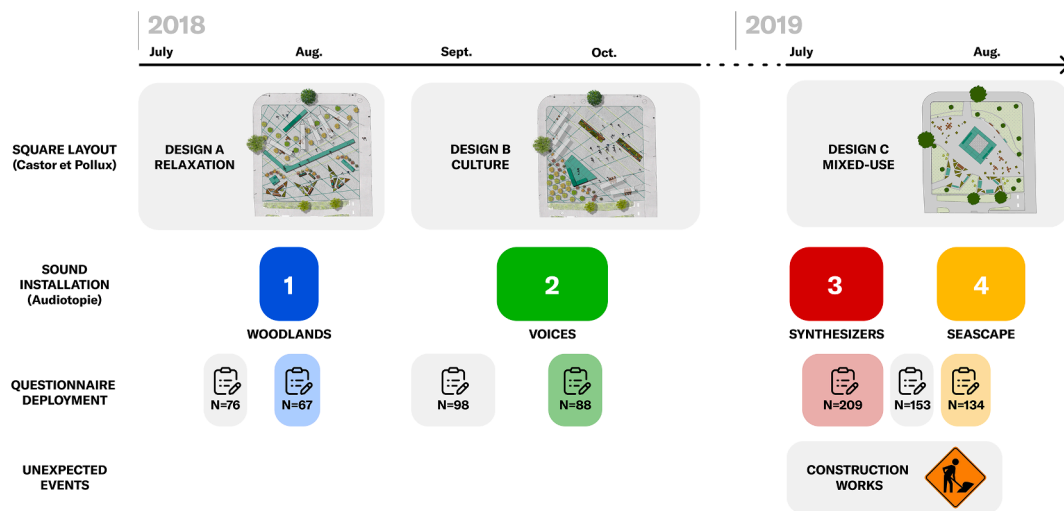


Fig. 3. Timeline of the project, including duration of installation for the space layouts, the sound installations, the data collection periods and associated sample sizes, and the presence of construction work in the summer 2019.

Audiotope.

Audio 4: excerpt of the Seascapes sound installation. Courtesy of Audiotope.

Overall and apart from Synthesizers that was only based on abstract sounds, all installations included both abstract and referential materials, some of which were meant to clearly emerge from the surrounding soundscape (Voices and Synthesizers) while others were more integrated (Woodlands and Seascapes).

2.3. Sound level measurements

We performed an acoustic characterization of the park through $L_{Aeq,10\text{ min}}$ measurements (24 in 2018 and 43 in 2019) taken with a B&K 2250 Sound Level Meter spread across Designs A and B in three different locations (P1 – northwestern corner adjacent to a commercial artery; P2 – center and P3 – southeastern corner close to residential buildings, see Fig. 1), covering weekdays and weekends (see Steele et al., 2019). In addition, a Noise Sentry NT sound level measurement station continuously recorded $L_{Aeq,1s}$ throughout the Spring and Summer of 2019, at the center of the space (close to position P2), from which we obtained daily profiles before and during construction (see Fraisse, 2019).

2.4. Soundscape assessments

2.4.1. Questionnaire

The research team deployed questionnaires (N=825 in total) across each condition, which comprised a combination of open and closed-ended questions. Participants were asked to rate their soundscape across 5-point Likert scales and to list the sounds they heard around them (see Table 1), as well as demographic and psychological information, and situational factors (e.g., age, gender, noise sensitivity, extraversion, activity, social interactions). Variations of the same questionnaire were deployed in 2018 (Designs A and B) and 2019 (Design C), the latter included additional soundscape scales. All questionnaires included the SSQP-PAQS scales (pleasant, eventful, vibrant, monotonous, calm, chaotic) with the exception of uneventful (which does not have an adequate translation in French, see Tarlao et al., 2023) and unpleasant (which is highly correlated with pleasant, see Tarlao et al., 2023). One PRSS scale was used in 2018 (taking a break from the daily routine) while the four components were used in 2019. Appropriateness (for activity, see Table 1) and perceived loudness were also included in the questionnaires. In addition, participants were asked to list the sounds they heard according to their valence: Pleasant, Unpleasant, Neutral. Participants were invited to list sound sources into each category.

Table 1
Questionnaire instrument: main variables.

Topic	Question – EN	Question – FR	Label	Conditions tested
SSQP – PAQS (Likert scales)	<i>I find this soundscape to be:</i>	<i>Je trouve l’ambiance sonore en ce lieu:</i>		
	Pleasant	Agréable	Pleasant	A, B, C
	Monotonous	Monotone	Monotonous	A, B, C
	Vibrant	Dynamique	Vibrant	A, B, C
	Chaotic	Chaotique	Chaotic	A, B, C
	Calm	Calme	Calm	A, B, C
Appropriate (Likert scale)	Appropriate for my activity	Appropriée pour mon activité	Appropriate	A, B, C
	Eventful	Animée	Eventful	A, B, C
Loudness (Likert scale)	I find the sound level here to be loud	Je trouve le niveau sonore élevé ici	Loudness	A, B, C
Restorativeness (Likert scales)	Spending time in this soundscape gives me a break from my day-to-day routine	Passer du temps dans cette ambiance sonore me permet de faire une pause dans ma routine quotidienne	Being-Away	A, B, C
	It is easy to do what I want while I am in this soundscape	Je trouve facile de faire ce que je veux quand je suis dans cette ambiance sonore	Compatibility	C
	The sounds fit together to form a coherent soundscape	Les bruits ensemble forment une ambiance sonore cohérente	Coherence	C
	Following what is going on in this soundscape really holds my interest	Suivre ce qui se passe dans cette ambiance sonore retient considérablement mon attention	Fascination	C
Sound sources (Free responses)	<i>Please list below the sounds/noises that you are hearing around you into the column that applies.</i>	<i>Listez ci-dessous les sons et bruits que vous entendez dans ce lieu en ce moment, dans la colonne correspondante</i>		
	Pleasant	Agréable	Pleasant sources	A, B, C
	Unpleasant	Désagréable	Unpleasant sources	A, B, C
	Neutral	Neutre	Neutral sources	A, B, C

2.4.2. Recruitment and respondents

Passers-by were approached after spending a few minutes in the park and invited to fill out voluntarily the questionnaire in either French or English (consistent with the university’s ethic certificate; REB #55–0615). Researchers tracked the location within the space for each respondent. Questionnaires were administered over 26 sessions, from 11 am to 9 pm in 2018, and from 9 am to 9 pm in 2019. The data collection sessions varied in length based on weather conditions and respondent availability and took place across weekdays (N=16) and weekends (N=10), both in presence and in absence of the sound installations (see Fig. 3), at comparable time periods to allow the comparison.

In total, 825 respondents answered the questionnaires, with age ranging from 18 to 86 (mean age = 34.8 ± 14), and a majority of French speakers (FR: 648; EN: 177), women (women: 421; men: 380; other/prefer not to say: 22), and groups (groups: 515; person alone: 289). Participants in groups were filling out the questionnaires separately. Following our observation of potential temporal variations during Designs A and B (see Tarlao et al., 2022), we ensured a more systematic data collection in Design C with sessions throughout the time of the day and day of the week, resulting in more questionnaires in Design C (N=496) than in Designs A (N=143) and B (N=186).

2.5. Data processing and analysis

2.5.1. Soundscape Scales

Statistical analyses were computed in R 4.3.0 with RStudio 2023.06.0 + 421 for Windows, with a statistical significance level of 0.05. Prior to the analysis, the Likert scales were converted to numbers (from 1 = Strongly Disagree to 5 = Strongly Agree). Depending on the scale, missing values ranged from 1.7 % (loudness) to 5.9 % (monotonous) and were replaced with the mean value of that scale, collapsed over all conditions. The data was highly non-normal so we ran semi-parametric and non-parametric analyses. To determine whether the sound installations had an effect on soundscape ratings, we conducted semi-parametric MANOVAs for each design with the Likert scales as dependent variables and the presence of the sound installations as independent variables using the *MANOVA.RM* package (Friedrich et al., 2018). Because sample sizes can be small, we report on the Modified

ANOVA-Type statistic (MATS) using wild bootstrap resampling method for p-values, with 10,000 iterations. We follow up with *post hoc* Mann Whitney U tests for each design, with Benjamin-Hochberg p-value correction. For each Mann Whitney U test, we report p-values and *r* effect sizes estimated using the package *rstatix*. Due to concerns related with Design A’s sample sizes when subdividing data according to location, an *a posteriori* power analysis for sample size requirement was conducted using the package *WMWssp* (see Happ et al., 2019).

2.5.2. Sound Sources Mentions

Sound sources were analyzed by classifying verbal units into semantic classes following Brown and colleagues’ classification scheme (Brown et al., 2016). Sources could belong to more than one valence category (pleasant, unpleasant, neutral). This paper focuses on the main categories that emerged from the analysis (capitalized here, see examples in Table A–1), which related either to human activity (e.g., TRAFFIC, AIR CONDITIONER, CONSTRUCTION), human presence (e.g., VOICE, HUMAN MOVEMENT) or nature (e.g., BIRDS, WIND, NATURE).

Following this categorization, each response was recoded using a binary code indicating whether or not the source was mentioned for each valence category (e.g., pleasant mention of birds: Y/N). The same category of sources was rarely mentioned twice by the same person for the same valence (e.g., trucks and cars both mentioned as unpleasant); however, sources of one category were sometimes mentioned by the same participant as having different valences (e.g. for TRAFFIC, garbage trucks as unpleasant and cars as neutral). Only participants that identified at least one sound source and were thus considered to have completed the task were included in the sound source analyses, representing respectively 95 %, 91 % and 87 % of respondents for Designs A, B and C.

To evaluate the effect of sound installations on sound source mentions, we performed Multivariate Binary Logistic Regressions (MBLRs), with the binary variables associated with source categories and valences as dependent variables, and the presence of the sound installations as the independent variable for each model. Compared to (univariate) binary logistic regressions, MBLRs account for the dependency between sound source categories and allow modelling of two or more categorical outcomes (Gauvreau & Pagano, 1997). In the following analyses, separate

variables are used to account for both the sound source category and its associated valence (e.g., TRAFFIC – neutral and TRAFFIC – unpleasant). We only included variables with a minimum of 10 Events Per Variable (number of observations in the smaller of the two outcome groups divided by degrees of freedom required to represent all variables in the model [Peduzzi et al., 1996]) and we excluded explicit mentions of the sound installations. The MBLRs were carried out using vector generalized linear models with the R package VGAM (Yee, 2015).

3. Results

3.1. Pre-existing soundscapes

In the absence of soundscape interventions, 174 participants evaluated the soundscape similarly across Designs A (N=67) and B (N=98), see Fig. 4. These ratings serve as a baseline for evaluating the effects of the Woodlands and Voices sound installations in 2018 (respectively), while 153 ratings for Design C (in the absence of installations) serve as baseline for Synthesizers and Seascape installations in 2019. The baseline ratings indicate that the pre-existing soundscapes were perceived in 2018 as mildly pleasant without being particularly quiet, moderately eventful without being chaotic or monotonous. In 2019, construction works and associated decrease in traffic affected the park’s soundscape (see Fraisse, 2019). During construction (in July and August 2019), soundscape was rated as less pleasant, less calm, less coherent, and more chaotic than in the period preceding construction works (May and June 2019, reported in Fraisse, 2019). Outside construction time however, it was rated as being less loud and less chaotic than in May and June, likely due to traffic calming (see July and August data in Fig. 4).

In 2018 (Designs A and B), participants listed on average 1.4 pleasant sources, 0.9 unpleasant source and 0.7 neutral source. The sound sources mentioned in Designs A and B show similarities (Fig. 5), and were typical of urban soundscapes (see for instance Ma et al., 2021): negative sources mostly consist in road traffic, which is the most mentioned source (around 75 % of respondents). Sources listed as pleasant are more diverse and typically include natural sounds (e.g., birds, water, wind) and sounds related to human presence (voice and human movement). Neutral sound sources are less frequently mentioned and refer mostly to traffic or human presence. In 2019 (Fig. 5), during construction time, participants listed on average 1.5 unpleasant sound sources, most often referring to road traffic (65 % of respondents) and construction (60 % of respondents). Pleasant sources (listed 1.1 times on average) include natural and human sounds as in 2018. Neutral sources are listed 0.6 times on average and are again associated with either traffic or human

presence. Outside construction time, listings are similar to 2018, with the exception of the air conditioning and birds that are more often mentioned, and less mentions of traffic.

3.2. Sound levels

Equivalent levels ($L_{Aeq,10min}$) recorded in 2018 across Designs A and B range from 57.3 dBA to 66.5 dBA, which is typical of a small park exposed to traffic noise (e.g., see Meng & Kang, 2016). These punctual measurements do not allow to evaluate the influence of either of the Woodlands or Voices installation on long-term sound level profiles, but they revealed that the upper half of the space, along the commercial artery, was louder (P1 range: 61.9–66.5 dBA) than the middle and lower half (P2 range: 57.9–61.7 dBA; P3 range: 57.3–61.4), abutting residential buildings (see Steele et al., 2019).

In 2019, differences of $L_{Aeq,10min}$ values between the three measurement points for Design C were similar to what was observed in Designs A and B, confirming the presence of a “quiet” side and a “noisy” side of the space (62.4 dBA at average at position P1, 58.3 dBA for P2 and 58.4 for P3, see Fraisse, 2019). This time however, construction works in the adjacent street (see Fig. 3) had a substantial impact on the sound environment, adding construction noise and reducing traffic noise. The construction works led to similar daily acoustic profiles and equivalent levels during construction time (from 8 am to 3:30 pm on weekdays) and lower sound levels outside construction time (after 3:30 pm on weekdays and on weekends), as compared to before the construction began (see Fraisse, 2019). Comparing daytime equivalent levels in July 2019 with and without the installations ($L_{Aeq,12h}$ from 7 am to 7 pm, on weekdays) shows a slight increase under the Synthesizers sound installation and no difference under the Seascape installation (No intervention: 61.3 dBA; Synthesizers: 63.1 dBA; Seascape: 60.5 dBA).

3.3. DESIGN A: Woodlands installation

3.3.1. Effect on soundscape ratings

The sound installation (condition A – Woodlands) was designed to be heard only in the lower half of the space. We therefore report separate MANOVAs for each half (note that a two-way MANOVA, including location as a factor, yielded similar results). A MANOVA on the upper half of the space did not reveal a significant effect of the sound installation on soundscape scales (MATS \approx 6.3, $p \approx$ 0.64). Conversely, the MANOVA on the lower half of the space shows a significant effect of the sound installation on soundscape scales (MATS \approx 26.2, $p \approx$ 0.034). According to follow-up Mann Whitney U tests (see Table A–2 and Fig. 6)

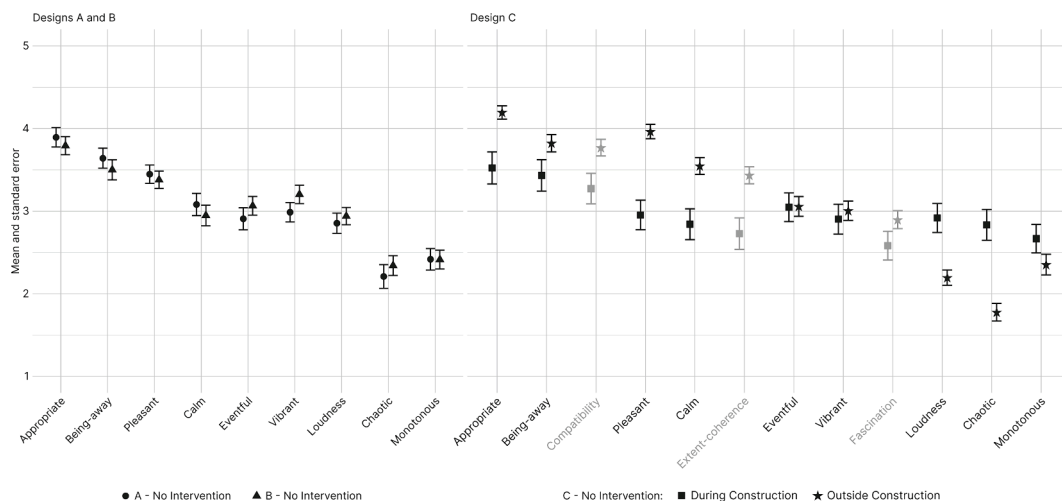


Fig. 4. Mean soundscape ratings and standard errors, collapsed over all participants for each space design, without sound installations. Left: Designs A (N=76) and B (N=98). Right: Design C during Construction (N=44) and outside Construction (N=109). Scales only used for Design C are shown in grey.

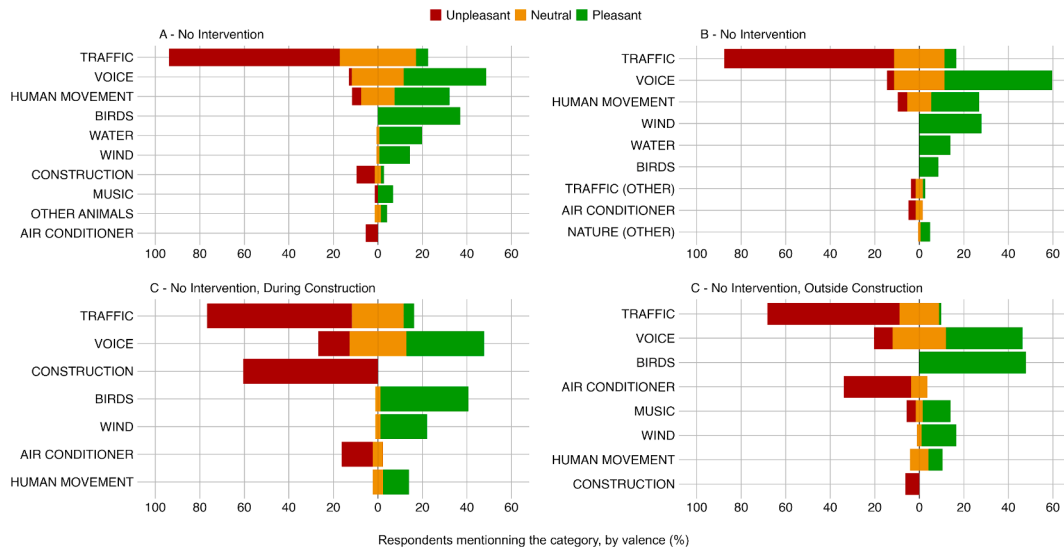


Fig. 5. Proportions of sound sources mentioned by category and valence, collapsed over all participants for each space design, without sound installations. Top: Designs A (N=73) and B (N=93). Bottom: Design C during Construction (N=43) and outside Construction (N=96). Only sound sources mentioned by more than 5 % of respondents are included. Sources are sorted from most to least frequently mentioned.

the sound installation led to a significant decrease in perceived sound level ($p \approx 0.03$, $r \approx 0.39$). Effect size estimates also suggest that the sound installation also led to respondents rating the soundscape as Calmer ($p \approx 0.08$, $r \approx 0.31$) and more conducive to restorativeness (Being-Away; $p \approx 0.08$, $r \approx 0.30$). A *posteriori* sample size requirement estimations using observed data indicate that a minimum sampling size of 77 (for *Calm*) and 84 (for *Being-Away*) would have been required to detect an effect of sound installation on these scales with a significance rate of 0.95 and a power of 0.8.

3.3.2. Effect on sound source mentions

We report here on separate MBLRs for each half of the space for sound sources listed as either pleasant, unpleasant or neutral.

In the upper half of the space (82 respondents), at least ten participants mentioned BIRDS (N=24), WIND (N=15), HUMAN MOVEMENT (N=17) and VOICE (N=36) as pleasant sources, TRAFFIC (N=19) and VOICE (N=22) as neutral sources, and TRAFFIC (N=39) as unpleasant sources. A MBLR (Table A-3) shows that on this side of the space, the mentions of traffic as neutral and sounds related to human movement as

pleasant were significantly reduced in presence of the Woodlands sound installation (Fig. 7).

In the lower half of the space (54 respondents), BIRDS (N=20), WATER (N=22), VOICE (N=21) and HUMAN MOVEMENT (N=10) were mentioned by at least ten participants as pleasant sources, compared to TRAFFIC (N=14) and VOICE (N=12) described as neutral, and TRAFFIC (N=39) as unpleasant. A second MBLR (Table A-3) indicates that the presence of the Woodlands sound installation led to a significant decrease in birds mentions, suggesting that the sound installation has caused attentional masking of birds sounds. It should be noted that mentions of MUSIC, which were too low be added to the analysis, increased in the presence of the Woodlands installation (Fig. 7).

3.4. DESIGN B: Voices installation

3.4.1. Effect on soundscape ratings

A MANOVA on Design B reveals a significant effect of the Voices sound installation on soundscape evaluation (MATS ≈ 28.1 , $p \approx 0.012$).

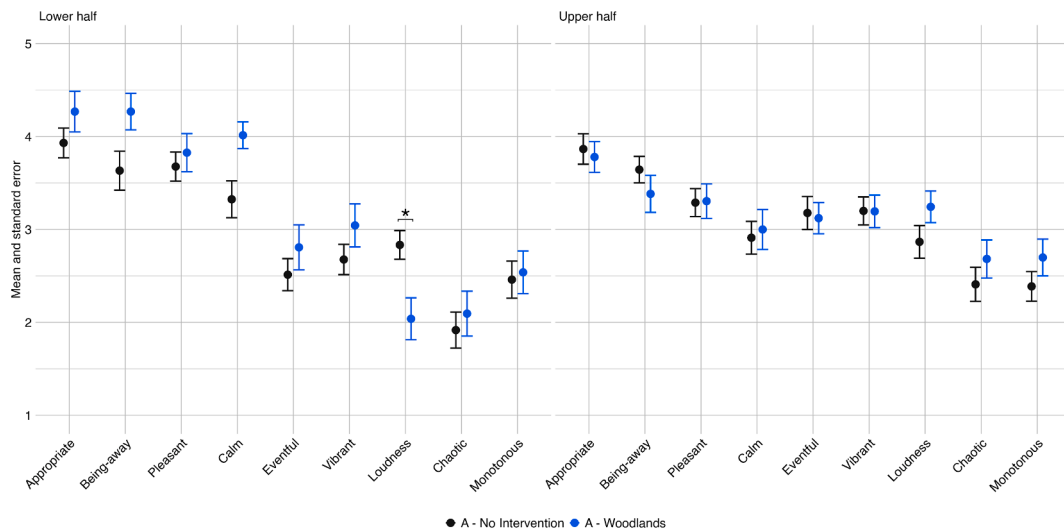


Fig. 6. Design A: Mean soundscape ratings with and without the Woodlands sound installation for both sides of the space in Design A (Upper half: N=86; Lower half: N=57). *, $p < 0.05$ (after applying Benjamin-Hochberg adjustment).

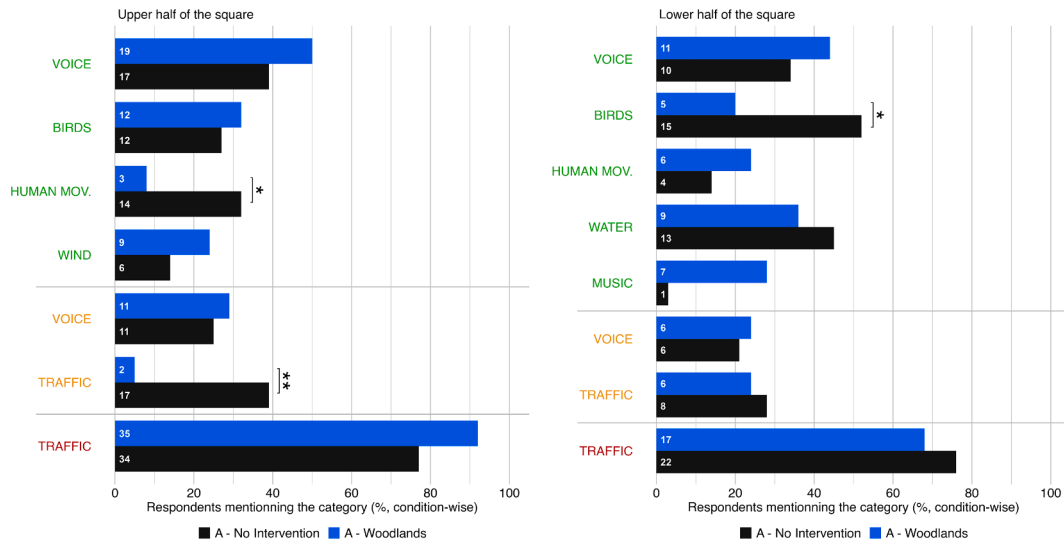


Fig. 7. Design A: Proportions of sound source categories (N=136). Categories in green were reported as pleasant, in orange as neutral, and in red as unpleasant. Numbers inside the bars indicate the number of respondents. Music mentions were not included in the regressions due to low EPV. *, $p < 0.05$; **, $p < 0.01$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Follow-up Mann Whitney U tests (see Table A-2 and Fig. 8) show that the sound installation led to a significant decrease in perceived sound level ($p \approx 0.0092$, $r \approx 0.24$) and increase in calm ($p \approx 0.0245$, $r \approx 0.20$).

3.4.2. Effect on sound sources mentions

We performed a MBLR (N=169) for pleasant, neutral, and unpleasant sound sources. Across the 169 participants who answered these questions, at least ten mentioned VOICE (N=76), WIND (N=42), HUMAN MOVEMENT (N=32), WATER (N=18), BIRDS (N=16), MUSIC (N=15) and TRAFFIC (N=10) as pleasant sources, TRAFFIC (N=40), VOICE (N=39) and HUMAN MOVEMENT (N=24) as neutral sources, and TRAFFIC (N=126) as unpleasant sources. A MBLR (Table A-4) indicates that the presence of the sound installation led to a significant increase in music mentions as pleasant (Fig. 9).

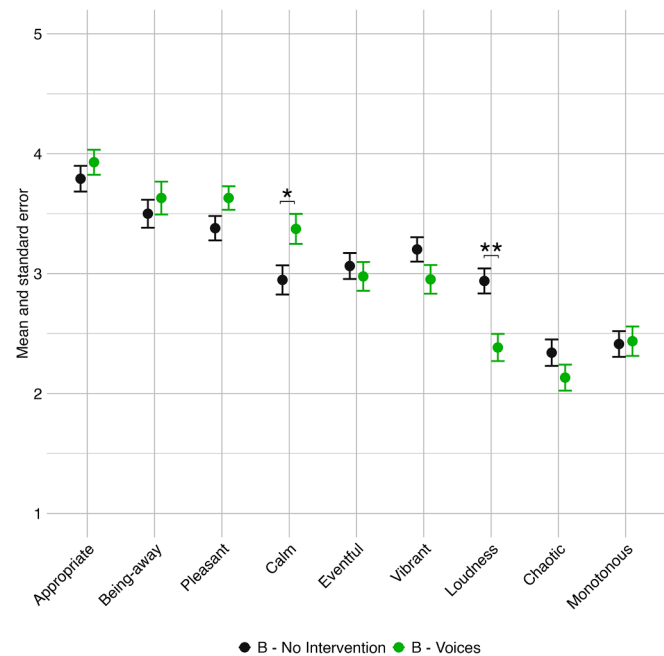


Fig. 8. Design B: Mean soundscape ratings with and without the Voices sound installation (N=186). *, $p < 0.05$; **, $p < 0.01$ (after applying Benjamin-Hochberg adjustment).

3.5. DESIGN C: Synthesizers and Seascape installations

3.5.1. Effect on soundscape ratings

A two-way MANOVA on Design C with construction work time and the condition (presence or absence of both sound installations) as independent variables reveal a significant effect of construction time (MATS ≈ 83.8 , $p < 0.001$) and of sound installations (MATS ≈ 98.2 , $p < 0.001$) on soundscape evaluation, as well as a significant interaction between construction time and condition (MATS ≈ 73.4 , $p \approx 0.002$). Follow-up MANOVAs reveal a significant effect of the sound installations on soundscape evaluation during construction time (MATS \approx

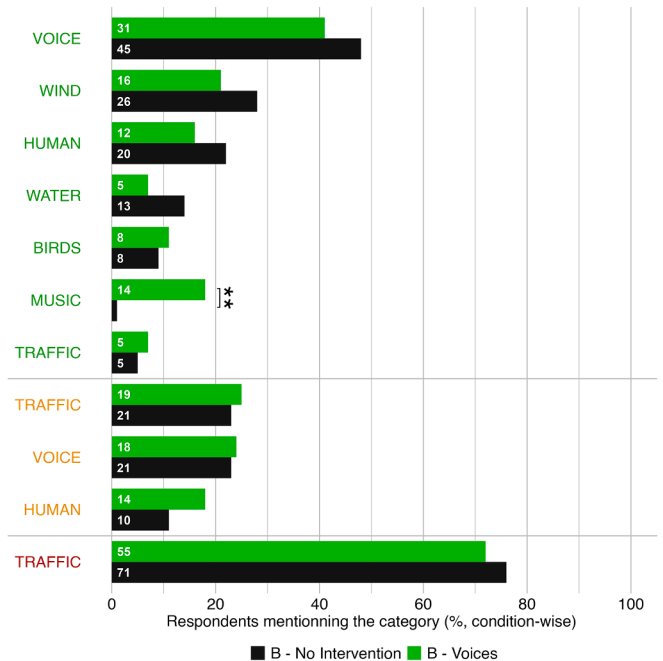


Fig. 9. Design B: Proportion of sound source categories (N=169). Categories in green were reported as pleasant, in orange as neutral, and in red as unpleasant. Numbers inside the bars indicate the number of respondents. *, $p < 0.05$; **, $p < 0.01$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

67.6, $p < 0.001$) but not outside of it (MATS ≈ 46.0 , $p \approx 0.302$). Post-hoc Mann Whitney U tests (see Table A-5 and Fig. 10) show that, during construction time, both installations led to a significantly more pleasant (Synthesizers: $p \approx 0.0054$, $r \approx 0.38$; Seascape: $p \approx 0.0282$, $r \approx 0.38$) and calmer soundscape (Synthesizers: $p \approx 0.0054$, $r \approx 0.37$; Seascape: $p \approx 0.0334$, $r \approx 0.34$) while the Synthesizers sound installation also led to a more coherent ($p \approx 0.0282$, $r \approx 0.32$) and less chaotic ($p \approx 0.0007$, $r \approx 0.31$) soundscape.

3.5.2. Effect on sound sources mentions

During construction time (N=120), twenty participants or more mentioned BIRDS (N=47) and VOICE (N=28) as pleasant sources, TRAFFIC (N=22) as neutral sources as well as TRAFFIC (N=68) and CONSTRUCTION (N=52) as unpleasant sources. A MBLR (Table A-6) during construction reveals that mentions of voice as pleasant sources and construction works as unpleasant sources significantly decreased in presence of the Synthesizers sound installation (pleasant music and neutral voices were not mentioned frequently enough to be included in the test). Conversely, the Seascapes installation led to an increase in mentions of birdsongs as pleasant sources and a decrease in mentions of construction work as unpleasant (see Table A-6 and Fig. 11).

Outside construction time (N=312), pleasant sources include BIRDS (N=111), MUSIC (N=84), VOICE (N=80) and WIND (N=80), neutral sources include VOICE (N=74), TRAFFIC (N=64) and HUMAN MOVEMENT (N=27), while unpleasant sources include TRAFFIC (N=144), AIR CONDITIONER (N=60), VOICE (N=21) and CONSTRUCTION (N=20). Another MBLR (Table A-6) outside construction time reveals a significant decrease in mentions of air conditioner as an unpleasant source in the presence of both installations, as well as decreases in mentions of birdsong and voice as pleasant sources and traffic as an unpleasant source and a significant increase in music as a pleasant source in presence of the Synthesizers installation (see Fig. 11). Additionally, we note the presence of mentions of water sounds (not included in the test) as pleasant in presence of the Seascape sound installation (see Table A-6 and Fig. 11).

4. Discussion

This study evaluated four sound installations deployed over two summers in the same public space, in close collaboration with sound artists and the city. This offered an unprecedented opportunity to systematically investigate the common and specific effects of sound installations in a public space. Indeed, this study demonstrated how sound

installations can overall enhance the experience of public space users, as soundscapes were rated as calmer in the presence of all four sound installations. Furthermore, our results show that tailored compositions can reinforce the purpose of a public space, with specific benefits associated with each of the compositions.

4.1. Implications for the planning and Design of public spaces

The analysis of soundscape ratings and sound sources heard indicate common beneficial effects across all four sound installations. Indeed, all the installations led to calmer soundscapes, while two of them—Synthesizers and Seascape—resulted in more pleasant soundscapes and the two others—Woodlands and Voices—in a reduction in perceived loudness. Together with previous studies on added sound in public spaces (e.g., Hong et al., 2020; Oberman et al., 2020; Steele et al., 2021), our unprecedented systematic in situ comparison converge to suggest that there are commonalities in the way sound installations can improve public space soundscapes. Other data-driven approaches might be useful to further investigate the nature of such commonalities in the presence of added sounds (e.g. Ooi et al., 2024).

Additionally, all installations led to an increase in mentions of sound sources directly related to the compositions, that is birds and water for Seascape, and music for all the others. Conversely, all installations except Voices led to a significant decrease in mentions of sound sources unrelated to the compositions, likely drawing participants' attention away from other sound sources. We call this effect *attentional masking*, also called *non-energetic masking* or *informational masking* elsewhere (Licitra et al., 2010; Hong et al., 2020; Oberman et al., 2020), to differentiate it from the physiological *informational masking* effect (Amiri & Jarollahi, 2020). In contrast with recent literature, this masking effect was observed not only for neutral and unpleasant sources, but also for pleasant sound sources. Further, attentional masking was consistently observed on non-dominant sources, regardless of their valence. For instance, traffic listed as unpleasant was significantly masked only when it was reduced (due to construction) and thus less dominant. This unprecedented finding is consistent with the intention of sound installations, typically not intended to dominate a soundscape (e.g., Anderson, 2008), in contrast with interventions designed as energetic maskers such as streams or fountains (e.g., Jeon et al., 2010). In terms of planning and design, this demonstrates that the addition of sounds to public spaces should be thought of as complementary to mitigation procedures (Brown & Muhar, 2004).

Together, these findings provide converging evidence for enhancing

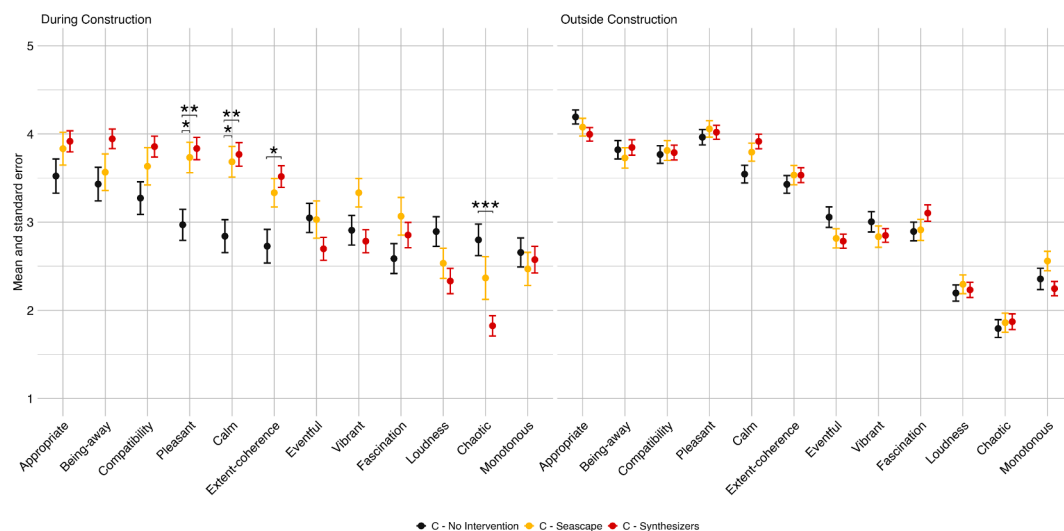


Fig. 10. Design C: Mean soundscape ratings with and without the Seascape and Synthesizers sound installations, during and outside construction time (During Construction: N=135; Outside Construction: N=361). *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$ (after applying Benjamin-Hochberg adjustment).

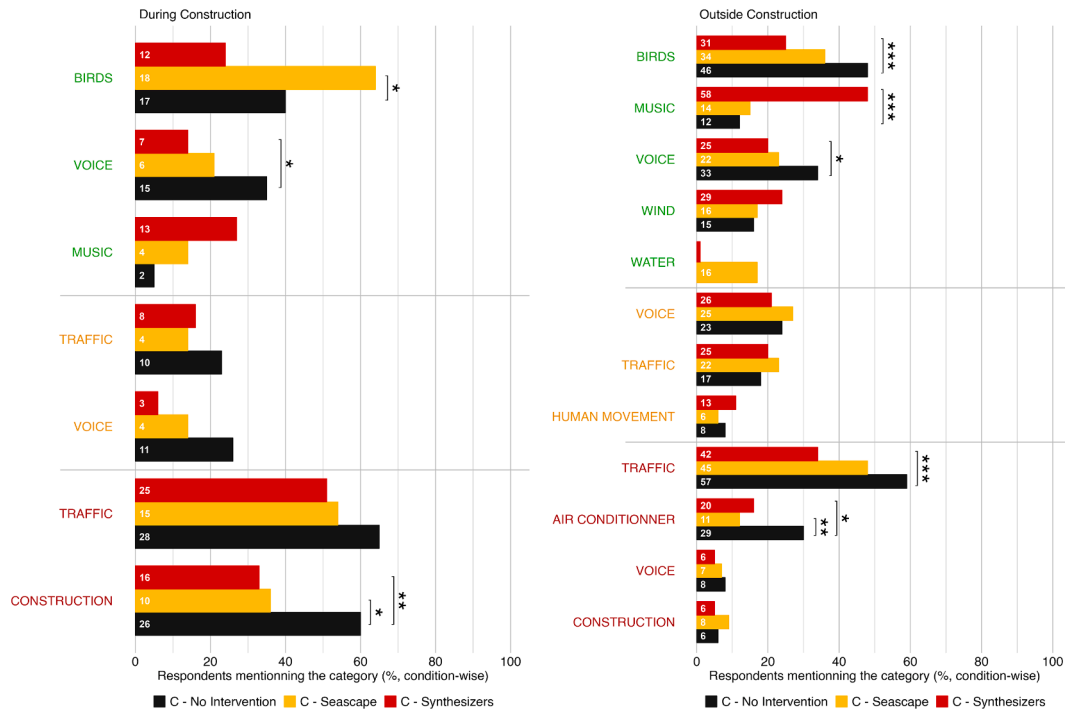


Fig. 11. Design C: Proportion of sound source categories (N=432). Categories in green were reported as pleasant, in orange as neutral, and in red as unpleasant. Numbers inside the bars indicate the number of respondents. Water mentions outside construction and music mentions during construction were not included in the regressions due to low EPV. *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

public space soundscape with sound installations. But another unprecedented result is the specific effects of each sound installations. The Woodlands installation—comprising natural sounds—increased the sense of being away, which is consistent with the installation’s goal of promoting relaxation and provides additional evidence of the restorative potential of natural sounds (see for instance Alvarsson et al., 2010; Hsieh et al., 2023). The Synthesizers installation—based on abstract sonic materials—led to a more coherent and less chaotic soundscape, and overall had the broadest effect on soundscape evaluation. This supports the hypothesis that abstract, acousmatic sounds are more likely to emerge from the background sound environment than referential materials, confirming recent laboratory observations (see Fraisse et al., in press). Finally, we show that the effects of the installations are not only specific to the composition, but may also depend on contextual variables such as time and space, confirming theoretical considerations from sound artists regarding *site specificity* (see for instance Tittel, 2009; Lacey, 2016). Overall, these results demonstrate that sound installations, and more generally soundscape design, can help reinforce the given purpose of a public space.

To summarize, we suggest that sound installations be added to the urban design toolkit as a relatively inexpensive, easy to implement, versatile (both in time and content), and efficient solution for soundscape design. This tool can also be useful for tactical urbanism (Di Croce & Guastavino, 2024): temporary installations, involving local stakeholders at different stages—from creation to evaluation, can engage communities in the design of long-term solutions to tailor the soundscape of public spaces to their specific needs. For instance, the soundscape ratings without construction and traffic noise confirm that removing unpleasant sources should be a priority. Nevertheless, the positive effect of both Design C installations in the presence of construction noise even though one of them led to slightly increased sound levels indicates that temporary installations can alleviate poor sound environments when unwanted sounds cannot be reduced. Judicious addition of sounds can also be advisable if removing the dominant noise source reveals a “bad” soundscape, as exemplified during the COVID

lockdown (Steele & Guastavino, 2021; Trudeau et al., 2023).

In short, the results highlight the strong potential of sound installations to enhance soundscapes with little risk of worsening the pre-existing sound environment, provided that it is not too loud (Yang & Kang, 2005; Hong et al., 2020), and that the design of the sound installation follows a careful process tailored to the site (Tittel, 2009; Lacey, 2016). Beyond their potential to improve a soundscape’s pleasantness or restorativeness, sound installations represent creative alternatives to “reveal the potentialities of a site” (Cobussen, 2023, p. 4) and can thus lead to new affordances, thanks to the unique expertise of sound artists. In that sense, the artists’ considerations of site-specific criteria is a key difference between sound installations (using curated content) and data-driven approaches, such as those involved in automatic soundscape augmentation (e.g., Ooi et al., 2022). Altogether, we believe that the creation of public space sound installation should be encouraged by urban planners, in accordance with other planning decisions that can have a direct consequence on sound (Tarlao et al., 2024).

4.2. Implications for the evaluation of soundscape interventions

Because the project revolved around the development of a new public space from a vacant lot, no prior information on how people used the space was available. Consequently, this research was iterative and exploratory. In the first year (Designs A and B), we discovered that day and time of use influenced the soundscape evaluations (Tarlao et al., 2022). We therefore refined the experimental design to cover a wider range of hours of use on both weekdays and weekends, thus increasing the total number of questionnaires collected in the second year (Design C). Large (and more balanced) datasets allowed us to detect finer effects and interactions for both installations. This study highlights the importance of assessing or controlling temporal and spatial variables when investigating the effect of a soundscape intervention on site.

Empirical evidence on the effects of soundscape interventions remains sparse (with the exception of fountains and natural features, see

Fiebig & Schulte-Fortkamp, 2023), as urban interventions in general are rarely evaluated and documented. In light of current efforts to establish standardized guidelines for soundscape interventions (ISO/AWI TS 12913-4, 2023), we suggest that existing tools provided by the ISO/TS 12913 series on soundscape (ISO TS 12913-1, 2014; ISO TS 12913-2, 2018; ISO TS 12913-3, 2019) should be complemented to capture the nuanced and sometimes unexpected effects of sound installations. For example, we were only able to capture the restorative effect of the Woodlands installations by including PRSS scales (Payne & Guastavino, 2018). Similarly, sound sources listings revealed a masking effect from the installations at a subordinate level of categorization (e.g., air conditioners for mechanical sounds, birds for nature sounds) that would not have been detected using the categories currently proposed in the ISO TS 12913-2:2018 for questionnaire data collection (although source listings are proposed for soundwalk data collection). Additionally, the use of source listings in addition to assessment scales offered more nuance to understand the effect of the installations on soundscape: although we did not detect a significant effect of either the Synthesizers and the Seascapes installations on soundscape ratings in the absence of construction works, sound sources listings revealed that both sound installations strongly altered the perception of the sound environment. Overall, these data collection tools are complementary, and the present study highlighted the need to triangulate methods, as recommended by the ISO (ISO TS 12913-3, 2019).

4.3. Limitations and future directions

As previously mentioned, due to the exploratory nature of our experimental design in the first year of data collection, Designs A and B were evaluated by small and imbalanced samples of participants. Thus, it is likely that some of our analysis did not have enough power to detect more subtle effects of the sound installations, or to disentangle the effects of confounding variables such as participants' gender or language. Further work is required to evaluate the effect of person-related factors (such as age, gender, noise sensitivity) and situational factors (such as activity and precise location in the space) likely to affect soundscape evaluation (Tarlao et al., 2021), as recent studies showed that added sounds' effect can be related to noise sensitivity (Steele et al., 2021) and can affect social interactions (Bild et al., 2016).

Additionally, both installations in Design C were designed to evolve through time according to space use patterns (see Guastavino et al., 2022). The presence of construction works through the entire implementation of both sound installations for Design C did not allow to investigate the effect of the compositions' temporal evolutions independently from construction time. Finally, the studied site was located in a central neighborhood, recognized for urban planning qualities (walkability, amenities, access to green spaces, etc.). Thus, these findings may not be transferable directly to different urban contexts but we posit that the underlying principles (e.g., a sound installation can mask non-dominant sources) still hold and can be tailored to other contexts. Furthermore, other research-creation collaborations revealed that dimensions rarely investigated by soundscape researchers but critical to sound artists, such as familiarity, impact soundscape assessment (see Fraisse et al., in press). We therefore advocate for a more open soundscape assessment strategy, one that leaves space for other practices (such as creative practices) and can inform research insights beyond pleasantness and eventfulness. Finally, we focused here on temporary installations, but the effects of a given sound installation are likely to evolve over long periods of time (i.e., months or years), as local residents and workers get used to it. Further research is required to investigate the long-term effects of sound installations on soundscape quality, assessments, and expectations.

5. Conclusion

The present study investigated the soundscape effects of four temporary sound installations in an urban public space. In line with previous research, the study confirms the existence of common effects of sound installations on soundscape: each installation increased the calm and pleasantness and/or reduced the perceived loudness of the soundscape. In addition, this systematic comparison enabled the detection of specific soundscape effects of the installations, in relation to their composition: abstract sounds were more likely to be noticeable, while nature sounds had a stronger potential for restorativeness. Additionally, results show that the installations distracted participants from other sound sources, given that they were non-dominant, and regardless of their valence. Ultimately, the soundscape effects of the sound installations were related to contextual factors such as time and space.

Confirming prior methodological findings, these results support the use of common soundscape scales in addition to restorativeness scales, while highlighting the benefits of triangulating them with more open questions, such as sound sources listings.

Overall, these results provide evidence for the potential of sound installations as low-cost creative solutions to support the intended design goals of public spaces. We recommend that sound installations be added to the urban design toolkit, as site-specific, tailored solutions complementing mitigation measures, to enhance the soundscape of public spaces and reinforce their vocation.

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CRediT authorship contribution statement

Valérian Fraisse: Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.
Cynthia Tarlao: Writing – review & editing, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.
Catherine Guastavino: Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix

Table A1

Emerging semantic classes of sound sources, using Brown and colleagues' classification scheme (Kang & Schulte-Fortkamp, 2015).

Semantic Class	Verbal Units (English)	Verbal Units (French)
TRAFFIC	cars, trucks, traffic, honk, honking, garbage truck, horns, street, vehicles, buses, tires, tire squeaks, motorcycles, cars driving smoothly, sirens, squeaking cars, police sirens	voitures, camion, auto, automobile, klaxon, moteur, circulation, motos, ambulance, scooter, trafic, camion poubelle, la rue, marche arrière, sirènes, véhicules, démarrage, police, autobus, accélération, chars, camion de déménagement, livraison, transports, freins, freinage, recul (camion), poids lourds, véhicule d'urgence, accélération des gros véhicules, camion frigorifique, camionnettes, claquage portière, crissement pneu, démarrage de moteur, ronron du scooter
OTHER TRAFFIC	jet engine from planes, planes, airplanes	klaxon de bateau, des bruits qui ressemble à un bateau, avions, bateau qui tange, bateau sur eau, bruit de bateau, bateau, cloches de bateau
AIR CONDITIONER	A/C, heater, radiator, fan, vent, air conditioner, mechanic shop noises	ventilation, ventilateur, clim, climatisation, air climatisé, aération (intermarché), A/C, air conditionné, compresseur (intermarché), échangeur d'air, fane derrière le marché, génératrice
CONSTRUCTION	trucks, engines, construction, cleaning machine, machines, road reparations, back alarm, pipe sounds, alarm pulses, engine, idling truck, loading, PVC pipe	construction, travaux, moteur, machine, machinerie, grue, marche arrière, reculons, scie, machinerie lourde, marteau-piqueur, pelle mécanique, perceuse, rénovation, tuyaux métal qui frottent, son d'industrie
BIRDS	birds, birds tweeting, seagulls	oiseaux, gazouillis des oiseaux, hiboux, mouettes
WIND	wind, breeze	vent, brise, vent dans les feuilles, vent dans les plantes, le mouvement des plantes
WATER	mist, sprinkler, fountain, rushing water, water spraying, water, hissing, waves	l'eau, brume, bruine, fuite d'eau, brumisateur, arrosage / arroseurs, fontaine, vapeur d'eau, eau qui gicle, gicleurs, vagues, mer, chutes, ruisseaux, gouttes d'eau
OTHER ANIMALS	dogs, dog barking, animals, insects	animaux, insecte, chien, aboiements, criquets, grillons
OTHER NATURE	trees, nature, plants, natural, forest, leaves	feuilles, plantes, arbres, nature, végétation, bruits de nature
VOICE	conversation, laughter, people talking, talking, kids, voices, chatting, children, people, people screaming, throat clearing, laugh, families	gens, rires, discussions, enfants, conversations, gens qui parlent, voix, gens qui discutent, personnes, les gens/les femmes qui jasant, personnes qui parlent, enfant/bébé qui pleure, interactions humaines, population, cris, les gens qui rigolent, personne qui parle fort, ça discute, des gens rient, babillages, bavardage, les gens qui s'amuse, phrases, femme au téléphone, hurlements
HUMAN MOVEMENT	bags of bottles, gravel, people dragging their feet, footsteps, rocky floor, walking, footsteps on the little rocks, foot traffic, bikes, bicycles, skateboards, clanking bottles	vélo, skateboard, planche à roulettes, bruit des pas sur le gravier, gravier, pas des passants, bruit de pas, piétons, pas des marcheurs, cyclistes, bicyclette, mouvements pédestres, chemin rocheux, roches, homme qui travaille, caisses de bière, bruits de gougone, rollerblade
MUSIC	music, chimes, drum noise, musical drone, light rhythms, meditation sound, mellow music, tribal sounds, xylophone, minor chords, tones	musique, notes, percussion, xylophone, musique méditative, musique relaxante, sons / musique apaisante, tambour, arrangement sonore, carillons éoliens, fond musical, jeux sonores, musique ambiance, musique détente, son asiatique, synth miroitant, flûte, balafon, piano, vélo festif, musique du bar
SOUND INSTALLATION	speaker, installation	hauts parleurs, bande son/bande sonore, enceintes, bande sonore de l'espace, boucle sonore et rythmique, diffusions acoustiques, installation, sons diffusés, sons enregistrés, speakers, sons ajoutés, extraits sonores, sons des haut-parleurs, bip bip (haut parleur)
COMMUNAL	church bells	cloches, cloches d'église
OTHER	beep, blop sounds, pulse sounds, alien sounding noise, beaming sound	bruit de toc/tic-toc, bip sonore intermittent, bulles, bruits du cosmos, jeux sonores, son asiatique, balles de ping pong, ondes continues, sons graves, toc tic toc, radar

Table A2

Designs A and B (2018): p-values and r effect size estimates for the difference in soundscape ratings between with and without the sound installation using Benjamin-Hochberg post-hoc Mann-Whitney U tests. Significant results at $p < 0.05$ in bold.

Soundscape Scale	Design A – Woodlands, lower half of the space (N=57)		Design B – Voices (N=186)	
	p	r	p	r
Pleasant	0.55	0.11	0.44	0.09
Appropriate	0.10	0.27	0.58	0.05
Calm	0.0778	0.31	0.0245	0.20
Being-away	0.0778	0.30	0.46	0.07
Eventful	0.43	0.14	0.58	0.05
Vibrant	0.21	0.21	0.24	0.13
Loudness	0.0296	0.39	0.0092	0.24
Chaotic	0.74	0.06	0.46	0.08
Monotonous	0.74	0.05	0.85	0.01

Table A3

Design A: Parameters estimation using MBLRs on sound source mentions with the presence of the Woodlands sound installation as a predictor, by valence and category (reference group is the condition with no intervention). Significant results at $p < 0.05$ in bold.

Condition	Location	Valence	Variable	Estimate (SE)	p
A – Woodlands	Upper half(N=82)	Pleasant	VOICE	0.46(0.45)	0.30
			BIRDS	0.21(0.49)	0.67
			HUMAN MOVEMENT	-1.69(0.68)	0.0131
		Neutral	WIND	0.67(0.58)	0.25
			VOICE	0.20(0.50)	0.69
			TRAFFIC	-2.43(0.79)	0.0021
	Lower half(N=54)	Unpleasant	TRAFFIC	1.23(0.70)	0.08
			Pleasant	VOICE	0.40(0.56)
		Neutral	BIRDS	-1.46(0.62)	0.0194
			HUMAN MOVEMENT	0.68(0.71)	0.34
			WATER	-0.37(0.56)	0.51
			VOICE	0.19(0.66)	0.77
Unpleasant	TRAFFIC	-0.19(0.63)	0.76		
	TRAFFIC	-0.39(0.61)	0.52		

Table A4

Design B: Parameters estimation using MBLR on sound source mentions with the presence of the Voices installation as a predictor, by valence and category (reference group is the condition with no intervention). Significant results at $p < 0.05$ in bold.

Condition	Valence	Variable	Estimate (SE)	p
B – Voices	Pleasant	VOICE	-0.31(0.31)	0.32
		WIND	-0.38(0.36)	0.30
		HUMAN MOVEMENT	-0.38(0.40)	0.35
		WATER	-0.84(0.55)	0.13
		BIRDS	0.22(0.53)	0.67
	MUSIC	3.03(1.05)	0.0038	
	ROAD	0.22(0.65)	0.74	
	Neutral	TRAFFIC	0.13(0.36)	0.71
		VOICE	0.06(0.37)	0.87
		HUMAN MOVEMENT	0.63(0.45)	0.16
Unpleasant	TRAFFIC	-0.51(0.35)	0.55	

Table A5

Design C (2019): p-values and r effect size estimates for the difference in soundscape ratings with either of the sound installations and between sound installations (conditions C – Synthesizers and C – Seascape) using Benjamin-Hochberg post-hoc Mann-Whitney U tests. Significant results at $p < 0.05$ in bold.

Soundscape Scale	No intervention – Synthesizers (N=105)		No intervention – Seascape (N=74)		Synthesizers – Seascape (N=91)	
	p	r	p	r	p	r
Pleasant	0.0054	0.38	0.0282	0.35	0.80	0.05
Appropriate	0.74	0.13	0.74	0.11	0.87	0.02
Calm	0.0054	0.37	0.0334	0.34	0.75	0.06
Compatibility	0.22	0.22	0.49	0.15	0.81	0.03
Extent-coherence	0.0282	0.32	0.15	0.26	0.74	0.07
Being-away	0.43	0.18	0.81	0.03	0.43	0.15
Eventful	0.31	0.20	0.80	0.05	0.45	0.15
Vibrant	0.74	0.06	0.22	0.24	0.09	0.29
Fascination	0.44	0.14	0.43	0.22	0.74	0.07
Loudness	0.15	0.25	0.43	0.18	0.56	0.10
Chaotic	0.0007	0.44	0.31	0.18	0.31	0.19
Monotonous	0.81	0.06	0.81	0.10	0.81	0.03

Table A6

Design C: Parameters estimation using two MBLR on sound source mentions (during and outside construction hours) with the presence of either Synthesizers or Seascape sound installations as predictors, by valence and category (reference group is the condition with no intervention). Significant results at $p < 0.05$ in bold.

Period	Condition	Valence	Variable	Estimate (SE)	p	
During Construction	C – Synthesizers	Pleasant	BIRDS	-0.70(0.46)	0.12	
			VOICE	-1.17(0.52)	0.0244	
		Neutral	TRAFFIC	-0.44(0.53)	0.41	
			Unpleasant	TRAFFIC	-0.48(0.50)	0.17
				CONSTRUCTION	-1.15(0.44)	0.0084

(continued on next page)

Table A6 (continued)

Period	Condition	Valence	Variable	Estimate (SE)	p
Outside Construction	C – Seascape	Pleasant	BIRDS	1.01(0.50)	0.0440
			VOICE	-0.67(0.56)	0.23
		Neutral	TRAFFIC	-0.60(0.65)	0.36
			TRAFFIC	-0.48(0.50)	0.33
		Unpleasant	CONSTRUCTION	-1.01(0.50)	0.0440
			BIRDS	-0.99(0.29)	0.0006
	C – Synthesizers	Pleasant	MUSIC	1.85(0.35)	0<.0001
			VOICE	-0.71(0.31)	0.0224
			WIND	0.52(0.35)	0.14
			VOICE	-0.15(0.33)	0.64
			TRAFFIC	0.18(0.35)	0.61
			HUMAN MOVEMENT	0.27(0.47)	0.56
		Neutral	TRAFFIC	-1.02(0.28)	0.0003
			AIR CONDITIONER	-0.79(0.33)	0.0166
			VOICE	-0.56(0.56)	0.31
		Unpleasant	CONSTRUCTION	-0.25(0.59)	0.67
			BIRDS	-0.48(0.29)	0.10
			MUSIC	0.20(0.42)	0.63
VOICE	-0.54(0.32)		0.09		
WIND	0.10(0.39)		0.79		
VOICE	0.41(0.33)		0.68		
Neutral	TRAFFIC	0.35(0.36)	0.33		
	HUMAN MOVEMENT	-0.29(0.56)	0.61		
	TRAFFIC	-0.46(0.29)	0.11		
	AIR CONDITIONER	-1.18(0.39)	0.0024		
	VOICE	-0.12(0.54)	0.82		
	CONSTRUCTION	0.33(0.56)	0.55		
C – Seascape	Pleasant	BIRDS	-0.48(0.29)	0.10	
		MUSIC	0.20(0.42)	0.63	
		VOICE	-0.54(0.32)	0.09	
		WIND	0.10(0.39)	0.79	
		VOICE	0.41(0.33)	0.68	
		TRAFFIC	0.35(0.36)	0.33	
	Neutral	HUMAN MOVEMENT	-0.29(0.56)	0.61	
		TRAFFIC	-0.46(0.29)	0.11	
		AIR CONDITIONER	-1.18(0.39)	0.0024	
	Unpleasant	VOICE	-0.12(0.54)	0.82	
		CONSTRUCTION	0.33(0.56)	0.55	
		CONSTRUCTION	0.33(0.56)	0.55	

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.landurbplan.2024.105173>.

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