Valérian Fraisse

FROM SOUND ART TO SOUNDSCAPE

a research-creation approach for designing and evaluating public space sound installations

FROM SOUND ART TO SOUNDSCAPE:

a research-creation approach for designing and evaluating public space sound installations

Valérian Fraisse

Schulich School of Music, McGill University, Montreal
École Doctorale SMAER, Sorbonne Université, Paris

Supervisors:	Dr. Catherine Guastavino	McGill University
	Dr. Marcelo M. Wanderley	McGill University
	Dr. Nicolas Misdariis	STMS IRCAM-CNRS-SU
Internal examiner:	Dr. Ilja Frissen	McGill University
External examiners:	Dr. Jordan Lacey	RMIT University
	Dr. William J. Davies	University of Salford
Defense committee:	Dr. Claudia Fritz	∂'Alembert CNRS-SU
	Dr. Cécile Regnault	EVS-LAURe CNRS-ENSAL

A thesis submitted to McGill University and Sorbonne Université in partial fulfillment of the requirements of the degree of Doctor of Philosophy in Music Technology.

Defended on November 27th, 2024, at McGill University.

À la mémoire de Philippe Fraisse.

un père incroyable et aimant, qui
restera à jamais un modèle et une
source d'inspiration personnels.

TABLE OF CONTENTS

ABSTRACT

Artistic expression through sound has always been a part of urban life, from street music to more recent sound installations. These forms of creation remind us that sound is not just a byproduct of the urban metabolism, but a resource with both negative and positive consequences. The soundscape approach seeks to address this complex reality through a human-centered approach to sound, from a design perspective. While this approach is well-established in research, the implementation of soundscape practices in urban design remains scarce. In particular, there seems to have been little attempt to provide methods derived from soundscape research to assist sound artists in the design of public space sound installations, and only a few studies have focused on the impact of such works on urban soundscapes. More research is needed to better understand the relationship between sound installation design and its effects on soundscape while providing artists with the resources to systematically assess the impact of their work before and after deployment.

To help fill this gap, this dissertation investigates the auditory experience of public space users in the presence of sound art with mixed methods approaches combining surveys, acoustic measurements, and interviews, on-site or in laboratory settings. The first chapter of this dissertation focuses on a field study about the design and evaluation of four temporary sound installations deployed in a small urban public space in Montreal, Canada. All four sound installations improved the public space's soundscape, with communalities and specificities related to compositional and contextual factors. The second chapter presents a laboratory study to inform the design of a permanent sound

installation that will be deployed in a larger public space in Paris, France, using a soundscape simulation tool designed for this purpose. Results validated the simulation tool and indicated three components relevant to evaluating sound installations: pleasantness, familiarity, and variety. Otherwise, the effects of the installation on familiarity and variety were stronger when composition sketches involved abstract sounds (sounds that were not clearly identifiable). The third chapter involves the laboratory evaluation of another permanent sound installation involving sounds evocative of the sea, currently deployed in a small urban public space in Montreal. Results indicate that some natural sounds can benefit the pre-existing soundscape, but a compromise has to be found between evocativeness and congruence: the most evocative sounds were also perceived as least pleasant because incongruent.

This dissertation provides theoretical, methodological, and practical contributions. The studies allowed us to investigate the relationship between the nature of a composition and its impact on soundscape while questioning the addition of generic sound sources—such as birdsongs and water stream sounds—as a blanket solution. In addition, these studies led to the development of a replicable and flexible methodology for the design of public space sound installations, in the form of a four-stage research-creation collaboration framework. Methodological tools were proposed for each of these stages, including a sound-level analysis tool, a soundscape simulation tool, and a questionnaire instrument. Finally, the collaborations provided invaluable data to the sound artists in their creative process and constituted a way to promote their work to public stakeholders.

RÉSUMÉ

L’expression artistique à travers le sonore a toujours fait partie de nos villes, qu’il s’agisse de musique de rue, ou plus récemment d’installations sonores. Ces formes d’expression nous rappellent que le sonore n’est pas simplement une forme de pollution résultant du fonctionnement des villes, mais également une ressource pouvant avoir des effets tout aussi bien positifs que négatifs. La recherche sur le paysage sonore permet d’envisager cette réalité complexe, à travers une approche du sonore centrée sur l’humain dans la conception de nos villes. Alors que cette approche scientifique est bien établie, peu de démarches informées par la recherche sur le paysage sonore sont réalisées en pratique. En particulier, il y a eu peu de tentatives de proposer des méthodologies pour aider les artistes sonores à concevoir des installations sonores dans l'espace public, et seules quelques études ont trait à l'impact de ce type d’œuvres sur le paysage sonore urbain. Plus d’études sont nécessaires pour mieux comprendre la relation entre la conception d'une installation sonore et ses effets sur le paysage sonore, tout en fournissant aux artistes les ressources nécessaires pour évaluer systématiquement l'impact de leur œuvre avant et après déploiement.

Pour combler cette lacune, cette thèse étudie la perception sonore des utilisateur·ices de l'espace public en présence d'art sonore à l'aide de méthodes mixtes combinant des enquêtes, des mesures acoustiques et des entretiens, sur site ou en laboratoire. Le premier chapitre de cette thèse se concentre sur une étude de terrain concernant la conception et l'évaluation de quatre installations sonores temporaires déployées dans un petit espace public urbain à Montréal, au Canada. Chaque installation a amélioré le paysage sonore,

avec des points communs et des spécificités liés à des facteurs compositionnels et contextuels. Le deuxième chapitre présente une étude de laboratoire visant à informer la conception d'une installation sonore permanente qui sera déployée dans un espace public plus vaste à Paris, en France, à l'aide d'un outil de simulation du paysage sonore conçu à cet effet. Les résultats ont validé l'outil de simulation et mis en évidence trois composantes pertinentes pour évaluer des installations sonores : l'agrément, la familiarité et la variété. Quant aux compositions, leurs effets sur la familiarité et la variété étaient plus fort lorsque les esquisses impliquaient des sons abstraits (qui n'étaient pas clairement identifiables). Le troisième chapitre porte sur l'évaluation en laboratoire d'une autre installation sonore permanente impliquant des sons évoquant la mer, actuellement déployée dans un petit espace public urbain à Montréal. Les résultats indiquent que certains sons naturels peuvent être bénéfiques pour le paysage sonore préexistant, mais qu'un compromis doit être trouvé entre caractère évocateur et congruence : les sons les plus évocateurs ont également été perçus comme les moins agréables parce qu'incongrus.

Cette dissertation apporte des contributions théoriques, méthodologiques et pratiques. Les études ont permis d'examiner la relation entre la nature d'une composition et son impact sur le paysage sonore, tout apportant des nuances quant à l'ajout de sources sonores génériques - telles que les chants d'oiseaux et les sons de cours d'eau. En outre, ces études ont conduit au développement d'une méthodologie reproductible et flexible pour la conception d'installations sonores dans l'espace public, sous la forme d'un cadre de collaboration de recherche-création en quatre étapes. Des outils méthodologiques ont été proposés pour chaque étape, avec notamment un outil d'analyse du niveau sonore, un outil de simulation du paysage sonore et un questionnaire. Enfin, les collaborations ont fourni des données inestimables aux artistes sonores dans leur processus de création et ont constitué un moyen de promouvoir leur travail auprès des pouvoirs publics.

ACKNOWLEDGEMENTS

First and foremost, I am extremely grateful to my supervisors. I was lucky enough to benefit from the guidance of three brilliant researchers and exceptional pedagogues throughout this 4-year journey. To Catherine Guastavino, who introduced me to the field of soundscape research 5 years ago, and who, since then, has thoroughly and unwaveringly mentored me with outstanding supervision and support. To Marcelo M. Wanderley, who also provided exceptional support and guidance throughout the thesis. To Nicolas Misdariis, who made the cotutelle possible and provided inestimable guidance and support, especially during my presence at IRCAM. I cannot stress enough how grateful I am to my three supervisors, for their exceptional supervisory and research qualities, but also for their human qualities. Thank you.

Of course, I am also deeply grateful to all the artists with whom I've been lucky enough to collaborate. None of this research would have been possible without them. Specifically, I thank Nadine Schütz, with whom we have carried out in-depth methodological work, numerous field recordings, listening sessions, intense discussions, and who contributed to a large part of the overall reflections that led to this thesis. I also thank Simone D'Ambrosio and Étienne Legast from Audiotopie, for their unwavering spirit of collaboration which laid the groundwork for this research. Finally, I thank Charles Montambault, with whom we have put together a fascinating case study to bring this research project to an insightful conclusion.

I wish to thank Jordan Lacey, Ilja Frissen, and William J. Davies for accepting the role of examiners of this manuscript. I also thank the defense committee members, Claudia Fritz and Cécile Regnault who accepted to be part of the jury. I am also grateful for the members of my thesis committee, Catherine Lavandier and Vincent Rioux, for their precious feedback along the course of my PhD. Setting up the international cotutelle between McGill University and Sorbonne Université involved a significant amount of administrative hassle, and I would also like to thank the administrative staff from both universities and especially Patricia Zizzo, Charlotte Vallin, Chloé Garcia, as well as Helene Drouin, who helped me throughout the PhD with a lot of patience.

There are a number of past or present doctoral and postdoctoral students and friends at IRCAM and McGill whom I also warmly thank for their support. On McGill's side, I give my most sincere thanks to the Sounds in the City team. In particular, I am deeply grateful to Cynthia Tarlao, who has been a real mentor and source of many scientific insights during my presence at McGill. I also thank Christopher Trudeau, Richard Yanaky, Josée Laplace, Edda Bild, and Daniel Steele for their warm team spirit and interesting discussions. On IRCAM's side, I give my heartfelt thanks to the Sound Perception & Design team for the great working environment and strong comradeship, and especially Baptiste Bouvier, Victor Rosi, Claire Richards, Nadia Guerouaou, and Pablo Arias. My deepest thanks to those who symbolically took part in this team for their friendship and the heart-warming spirit they conveyed, and especially Yann Teytaut and Constance Douwes. I would also like to thank Elise Nicolas and Clémentine Berger, exceptional students whom I was lucky enough to mentor during their internships.

Last but not least, I thank from the bottom of my heart my family and friends, which indirectly supported this project but provided invaluable personal support throughout the years. To my father, Philippe Fraisse, who was an exceptional human being with boundless curiosity and humanity. He was my first source of inspiration to follow my passions and question myself about the world around me. I dedicate this thesis to his memory. To my mother, Isabelle Fraisse, whose love and benevolence have never failed me and whose sensitivity to the arts has undoubtedly nurtured my curiosity and interest, while her devotion to my musical passions constitutes an important part of what I have become. To my sister and brother, Héloïse Fraisse and Corentin Fraisse, and the rest of my family, which have also been the foundation of my personal development. To my friends back in France, who have played an essential role in my life a and who I can't wait to see again, including but not limited to Thomas, Malo, Maxence, Cyril, Karim, Rubin, Justine, Camille, Antoine, and Donatien. To Camille Magnan, who supported me relentlessly over the last few years, both personally, but also with her exceptional design skills, which greatly contributed to the visuals presented in this research. Camille is the most wonderful companion I could have ever dreamed of. Finally, to my son Philémon Fraisse-Magnan, who also makes me immeasurably proud and happy, and for whom these works will hopefully be a source of inspiration to guide him towards his passions.

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ANOVA	Analysis Of VAriance
ATS	ANOVA-Type Statistics
CIRMMT	Centre for Interdisciplinary Research in Music Media and Technology
COST	Cooperation in Science and Technology
CRESSON	Centre de Recherche sur l'Espace SONore et l'environnement urbain
FFT	Fast Fourier Transform
FOA	First-Order Ambisonics
HOA	Higher-Order Ambisonics
IRCAM	Institute for Research and Coordination in Acoustics/Music
ISO	International Organization for Standardization
KMO	Kaiser-Meyer-Olkin test
LUFS	Loudness Units relative to Full Scale
MANOVA	Multivariate Analysis Of VAriance
MATS	Modified ANOVA-Type Statistics
MBLR	Multivariate Binary Logistic Regression
Mdn	Median
MDS	MultiDimensional Scaling
MILSON	Pour une anthropologie de MILieux SONores
PAQS	Perceived Affective Quality Scales
PCA	Principal Components Analysis
PeRL	Performance Research Laboratory
PRSS	Perceived Restorativeness Soundscape Scales
PSP	Positive Soundscape Project
SSQP	Swedish Soundscape Quality Protocol
SMACOF	Scaling by MAjorizing a COmplicated Function
WSP	World Soundscape Project

CONTRIBUTION OF AUTHORS

This dissertation has been prepared as a manuscript-based thesis and includes the following publications. The research and results are my own original work carried out under the guidance of my supervisors, Dr. Catherine Guastavino, Dr. Marcelo M. Wanderley, and Dr. Nicolas Misdariis, with contributions from others as described below. For each co-authored section (chapters 2, 3, 4 and section 5.3 from chapter 5), I was the lead researcher, contributed to data collection (chapter 2) or performed the entirety of the human data collection, led the methodological development, conceptualization, investigation (chapters 3 and 4), and software development and management. I was responsible for data curation, formal analysis, visualization, and wrote the original drafts (except for the sections describing the installations and the compositions, drafted by the sound artists), which were then reviewed by my co-authors.

The studies in this thesis were funded by grants from the Social Sciences and Humanities Research Council of Canada [SSHRC, #890-2017-0065 to CG, Sounds in the City], the Natural Sciences and Engineering Research Council of Canada [NSERC, Discovery Grant #2019-04551 to MW; Discovery Grant #2019-06121 and Acceleration Supplement #0035-2019 to CG], an internship program with ExperiSens funded by the Fonds de Recherche Nature et Technologies of Quebec's [FRQNT, #323293 to VF], Sorbonne Université's Aide Spécifique aux Doctorants Boursiers, as well as McGill's Graduate Mobility Award.

Chapter 2

Fraisse, V., Tarlao, C., & Guastavino, C. (2024). Shaping City Soundscapes: In-Situ Evaluation of Four Sound Installations in an Urban Public Space. *Landscape and Urban Planning*, *251*, 105173. https://doi.org/10.1016/j.landurbplan.2024.105173

Dr. Cynthia Tarlao contributed conceptual, statistical and writing guidance, and was also involved throughout the data collection and curation. The project as a whole was the result of a collaboration between the Sounds in the City research partnership, the sound design firm Audiotopie and the Arrondissement Plateau-Mont-Royal of Ville de Montréal. Sounds in the City past or present members Daniel Steele, Christopher Trudeau, Mariana Mejía Ahrens, Gregoire Blanc, Sarah Bogdanovitch, and Edda Bild contributed to experimental design and data collection. Audiotopie designed the temporary sound installations (composers: Étienne Legast, Simone D'Ambrosio, and Lou Duchemin-Lenquette; technical assistance: Étienne Carrier). Plateau-Mont-Royal provided assistance throughout the project, allowing our team to conduct research in the public space and helping with the acoustic measurements, especially Maryse Lavoie.

Ethical approval for this project was given by McGill research ethics board [REB #55-0615].

Preliminary reports of the results were first published in:

- Fraisse, V. (2019). Improving Urban Soundscapes through Sound Installations: An in situ Study in a Montreal Pocket Park. [Master's Thesis]. IRCAM.
- Fraisse, V., Steele, D., D'Ambrosio, S., & Guastavino, C. (2020). Shaping urban soundscapes through sound art: A case study in a public square exposed to construction noise. International Workshop on Haptic and Audio Interaction Design. https://hal.archives-ouvertes.fr/hal-02901201
- Steele, D., Legast, É., Trudeau, C., Fraisse, V., & Guastavino, C. (2019). Sounds in the City: Improving the soundscape of a public square through sound art. International Congress on Sound and Vibration.

A book chapter describing the research-creation collaboration has also been published in:

- Guastavino, C., Fraisse, V., D'Ambrosio, S., Legast, E., & Lavoie, M. (2022). Designing Sound Installations in Public Spaces: A Collaborative Research-Creation Approach. In *Designing Interactions for Music and Sound*. Focal Press.

In the dissertation and corresponding article, I compiled and re-analyzed all the data collected by the team over the 2 summers of data collection under the guidance of my co-authors. This analysis was informed by reflections emerging from the other two case studies reported in chapters 3 and 4. I drafted the entire article which was reviewed by my co-authors.

Chapter 3

Fraisse, V., Schütz, N., Wanderley, M. M., Guastavino, C., & Misdariis, N. (2024). Using Soundscape Simulation to Evaluate Compositions for a Public Space Sound Installation. *Journal of the Acoustical Society of America*, *156*(2), 1183-1201. https://doi.org/10.1121/10.0028184

This paper reports a study that is part of a still-ongoing collaboration with sound artist Dr. Nadine Schütz, who composed the different conditions and contributed to conceptualization, methodology, data collection (field recordings), and wrote the sections describing the installations. Additionally, Coralie Vincent, Elise Nicolas, and Antoine Le Dreff assisted with data collection (field recordings and acoustic measurements), as well as the BruitParif organization, and especially Fanny Mietlicki and Carlos Ribeiro (acoustic measurements). Finally, Dr. Benoit Alary and Dr. Olivier Warusfel provided technical and scientific guidance.

This research has been approved by McGill research ethics board [REB #22-01-033] and by Sorbonne University Research Ethics Committee [CER-2021-109].

Preliminary reports of early stages of the project were published in:

- Fraisse, V., Nicolas, E., Schütz, N., Ribeiro, C., & Misdariis, N. (2022). Évaluer l'impact d'installations sonores sur la perception du paysage sonore urbain: Cas d'étude d'une place publique parisienne. *16e Congrès Français d'Acoustique*.

- Fraisse, V., Schütz, N., Wanderley, M., Guastavino, C., & Misdariis, N. (2022). Informing sound art design in public space through soundscape simulation. *In INTERNOISE and NOISE-CON Congress and Conference Proceedings (Vol. 265, No. 4, pp. 3015-3024).*

Chapter 4

Fraisse, V., Montambault, C., Wanderley, M. M., & Guastavino, C. (Manuscript to be submitted). Bringing the coastline to the city: Laboratory evaluation of a public space sound installation with residents.

This paper reports a study that is part of another still-ongoing collaboration with sound artist Charles Montambault, who composed the different conditions and contributed to conceptualization, data collection (field recordings), and wrote the sections describing the installations. Laëtitia Matrat and Marie-Flore Dérival from the Institut de tourisme et d'hôtellerie du Québec's ExperiSens also helped with recruitment.

This research has been approved by McGill research ethics board [REB # 23-05-049].

Chapter 5

Section 5.3 of this chapter is a rework of a conference paper published in:

Fraisse, V., Wanderley, M. M., Misdariis, N., & Guastavino, C. (2024). Designing Sound for Public Spaces Through a Research-Creation Collaboration Framework. *Design Research Society Conference*. https://doi.org/10.21606/drs.2024.1083

This paper is the result of my own reflections following the different studies reported in this thesis. Dr. Cynthia Tarlao was consulted for conceptualization and writing guidance.

CHAPTER 1. INTRODUCTION

Just as we share the air we breathe, we are submerged in a sea of shared sound.

Bruce Odland and Sam Auinger,
Reflections on the Sonic Commons

In our predominantly urbanized societies, sounds and human beings are inextricably intertwined. Sound shapes our daily lives as much as we shape our sound environment, through a swinging ballet governed by the ever-lasting flow of cities. When we think of urban sounds, the first things that usually come to mind are traffic noise, air conditioners, construction works, sirens, and so on. These sounds are the result of what could be called the *functionalist imperatives* of cities (Lacey, 2016, pp. 10-15). These first thoughts are legitimate, given the omnipresence of mechanical sounds in urban environments and their dramatic consequences on humans and animals alike (e.g., see Erbe et al., 2022; United Nations Environment Programme, 2022). But sounds are not just a by-product of urban metabolism: they mediate, or create relationships between listeners and their environment (Truax, 1984). Just as sounds can annoy us, distract us, or even negatively affect our health and well-being, they can also relax us, restore us, provide enjoyment or excitement, foster cultural bonds, to name but a few. In short, sound can be approached as a *resource* rather than a *waste* (Brown, 2010).

1.1. Soundscape

Distinct but complementary to environmental noise management approaches, the s*oundscape* approach shares this perspective, emphasizing the potential benefits of the acoustic environment (Brown, 2010). The notion of soundscape was first coined by Southworth (1969) and further fleshed out by Schafer (1977) with the World Soundscape Project (WSP), an educational and research group aimed at drawing attention to the sonic environment through a human-centered perspective. Led by a group of composers, the WSP was mainly driven by aesthetic concerns, with limited practical applications (Lacey, 2019). However, it initiated a paradigm shift in repositioning city sound discussions from a waste to a resource amenable to design. Several multidisciplinary research projects involving researchers and artists will follow this lead, including Pour une anthropologie de MILieux SONores (MILSON, see MILSON, 2024), the Centre de Recherche sur l'Espace SONore et l'environnement urbain (CRESSON, see Augoyard & Torgue, 2006), or the Positive Soundscape Project (PSP, see Davies et al., 2007). In the last two decades, the soundscape approach received significant attention in the fields of community noise and environmental acoustics, with the worldwide spread of soundscape sessions in acoustical associations, the advent of special issues on soundscape in scholarly journals, and research initiatives such as the interdisciplinary research network on the Soundscape of European Cities and Landscape through the COST (Cooperation in science and Technology) Action TD0804 program led by Jian Kang from 2009 to 2012 (Guastavino, 2020). Meanwhile, the focus has gradually shifted from humanities and artistic research towards more engineering and planning-oriented domains, emphasizing a data-driven approach (Lacey, 2019). This is well illustrated by the recent efforts from the International Organization for Standardization (ISO) to normalize the soundscape approach among urban stakeholders (ISO TS 12913-1, 2014; ISO TS 12913-2, 2018; ISO TS 12913-3, 2019)[1].

Soundscape [2], understood here as "[the] acoustic environment as perceived or experienced and/or understood by a person or people, in context" (ISO TS 12913-1, 2014, p. 1), supports a holistic approach to sound environments. This perspective considers the

[1] See (Guastavino, 2021) for an in-depth historical overview.
[2] There is an ongoing debate on the relevance of the term, especially among scholars in contemporary sound studies, but this will not be addressed here. See Lacey's (2016) discussion on the matter.

core psychosocial processes (feelings, meanings, thoughts) that influence how people or communities experience sounds in a given space, in relation to its context and the activities taking place within it (Herranz-Pascual et al., 2010). By focusing comprehensively on the auditory experience, sound can be intentionally designed and planned with its benefits in mind (Bild, Coler, et al., 2016; Brown & Muhar, 2004). However, integrating the human experience of sound environments into urban planning and design is a complex task, as it demands tailored and contextualized decisions. Moreover, it requires engaging a diverse range of stakeholders, given that urban sound management operates at various scales (Moshona et al., 2024; Tarlao et al., 2024)—from international policies (e.g. European Commission, 2024) and large-scale urban planning efforts (e.g., pedestrianization of a neighborhood) to small-scale interventions in public spaces (e.g. public space sound installations). Despite increasing academic interest, this intricateness hinders the practical adoption of the soundscape approach, with limited application cases available for practitioners (Steele et al., 2023). To this day, bridging soundscape research and urban planning and design is recognized as the biggest challenge in urban soundscape research (Aletta & Xiao, 2018).

To address this research-practice gap, there is an increasing interest for urban design projects that incorporate the human experience of sound environments through *soundscape interventions*. Defined as "site-specific design[s] aimed at preserving or improving an acoustic environment" (Moshona et al., 2024, p. 10), these real world applications can be characterized using Cerwén and colleagues' (2017) framework, which outlines three key approaches to guide the design of soundscape interventions in noise-exposed developments: 1) the localization of functions; 2) the reduction of unwanted sounds; and 3) the introduction of wanted sounds. The first approach considers the pre-existing sonic characteristics of the site in relation to the surrounding built environment. The second approach involves measures such as implementing noise barriers or reducing traffic volume and speed, aligning with traditional noise mitigation strategies (see the guidelines recently proposed by the World Health Organization [2022]). The third approach focuses on improving the existing soundscape by introducing or reinforcing desirable sound sources. Strategies for this include masking unwanted noise with desired sounds, promoting natural sounds (e.g., fountains, vegetation to attract birds), encouraging human activities (e.g. playgrounds, kiosks), altering the acoustic properties of a space (e.g. mechanical resonances, gravel paths), adding music through loudspeakers, or deploying sound installations.

Overall, the growing interest for soundscape interventions is reflected in recent initiatives to establish implementation standards (ISO/AWI TS 12913-4, 2023). But the question then arises as to who possesses the necessary skills for implementing the said interventions. In the recent years, there have been a number of attempts to sensitize urban planners, architects, or policymakers to the soundscape approach. These include for instance workshops (e.g., see Cerwén et al., 2017; De Winne et al., 2020; Steele et al., 2020) the design of virtual reality tools for co-design exercises (Tarlao, Steele, et al., 2023) and individualized trainings (Yanaky et al., 2023), as well as formations in architectural design education programs (Hong & Chong, 2023; Milo, 2020; Xiao et al., 2022). Although these growing initiatives are crucial to sensitize urban designers to the importance of considering the city users' experience of their sound environment, it is still very rare for practitioners to operationalize the soundscape approach beyond noise mitigation (Steele et al., 2023; Tarlao et al., 2024). However, there is an urgency to pay more careful attention to the sonic (re)design of public spaces to achieve more bearable, livable, and diverse living environments. Despite the outreach efforts mentioned above, architects, urban planners, and other decision-makers remain generally ill-equipped to incorporate the soundscape approach into their designs, primarily because of a lack of training and resources. On the other hand, acousticians do not tend to focus on people's experiences of the sound environment beyond nuisance assessments (Brown, 2010), and are not formed to take into account the social, cultural, political, and aesthetic dimensions connected to sound. That being said, and as Cobussen (2023) points out, another group of stakeholders appears to meet all these criteria, at least at the scale of public spaces: sound artists.

1.2. Sound installation art

There are strong arguments for involving sound artists in the implementation of soundscape interventions, especially those that involve the (re)design of public spaces. To fully understand this, it is important to briefly consider the historical context of sound art practices (for an in-depth historical overview, see for instance LaBelle, 2006). The term *sound art* often faces criticism for its attempt to label a wide range of interstitial creative practices linked to various periods, movements, philosophies, and multifaceted approaches (Canonne & Fryberger, 2020; Kihm, 2020). Despite this diversity, sound art can categorize a set of practices sharing common grounds (Licht, 2009). Sound art is associated with a conception of sound as an aesthetic category, so that any sound might be a potential material for composition. In other words, sound art reconsiders the conventional distinction between "musical sounds" and "noise". This approach, which could be traced back to the early 20th century with the Futurist movement (Russolo, 1913), gained in momentum from the 50s onward, notably with John Cage's experimentations, Pierre Schaeffer's *musique concrète* works, and the associated theoretical frameworks (Cage, 1961; Schaeffer, 1966). Sound art also encourages to rethink the relationships between the composer, the interpret, and the audience. The Fluxus movement, for instance, involved many co-creative works where listeners were repositioned as participants, mostly in the 60s (Ouzounian, 2021). More recent approaches continue to question these relationships such as relational art and collective art forms, which encompass artistic practices where human relations and their social context as a whole are regarded as a point of departure for creation (Bryan-Kinns, 2014; Di Croce, 2020).

Sound art not only reassesses the aesthetic or relational qualities of sound, but also the interface between sound, time, and space. From the 60s onwards, the conceptual foundations of the Fluxus movement as well as of John Cage led artists to gradually reconsider the relationship between sound and its environment (Ouzounian, 2021). By the late 60s, Max Neuhaus initiated a significant shift by creating sound works outside traditional venues like concert halls and galleries, seeking new creative perspectives and broader audiences, out of the traditional art system (Neuhaus et al., 2018). These seminal works, which were later coined *sound installations*, initiated a new artistic practice that gradually emerged as a field on its own, attracting pioneering artists who sought to leave the institutional framework of museums and galleries, such as Bill Fontana, Bernhard Leitner, or Christina Kubisch (Licht, 2009; Tittel, 2009).

In the words of Bandt (2006), “sound installation can be defined as a place, which has been articulated spatially with sounding elements for the purpose of listening over a long time span” (p. 353). Whether experienced individually or collectively, sound installation art engages the audience in ways distinct from more predefined musical performances. Embedded in space, it invites the auditors to move around and mold their own spatial experience of the artwork. With no fixed duration, it unfolds over extended periods and has no clear beginning or end, such that the duration of engagement is determined by the audience (Bandt, 2006). These considerations take on particular significance when sound installations are *site-specific*, namely when they are tailored to specific locations (often outside the institutional umbrella of museums and galleries, in public or semi-public spaces), and have an interrelationship with this location (Tate, 2024). In public space specifically, creating a sound installation requires one to “deal with the fact that the place is a public domain” (Neuhaus & Des Jardins, 1994, p. 134): this requires considering either or all of the architectural, acoustic, social, cultural, political, historical, and experiential characteristics specific to the location (Klein, 2009; Tittel, 2009).

Of course, there are many ways to tackle site-specificity, and artists often have their own, distinctive approach to negotiating the relationship of their works to the surrounding space (Tittel, 2009). See for instance how the approach of Vogel (2013), with a focus on acoustics and perception, differs from that of someone like LaBelle (2018), who sets his works in relation to the local political and social context, or Schütz (2017), who seeks to integrate the sonic modality into the landscape design process. This is not to say that approaches for creating site-specific installations do not overlap across artists (nor that the approach of an artist is not subject to change over time). For instance, site-specific sound artists tend to emphasize on the importance of their own embodied experience of the site, and work as much as possible in situ (Robson et al., 2023). Overall, sound artists can propose tailored solutions for (re)designing public spaces, mediating between space users and the site by revealing its unique potentialities—be it in relation to its historical heritage, its social context, its architecture, or other aspects (Cobussen, 2023).

1.3. The role of sound installation art in soundscape research

The preceding discussion highlighted the points of intersection between the soundscape approach and sound installation art. We have shown that soundscape research is deeply concerned with how people perceive and respond to sound environments—a concern that resonates with the conceptual roots of sound art. Moreover, the necessity of contextual awareness in soundscape research parallels the importance of site-specificity in the design of public space sound installations. In fact, as previously mentioned, artistic research and thought were originally integrated into soundscape research, aligning with Schafer's (1977) vision that "the home territory of soundscape studies will be the middle ground between science, society, and the art" (p. 4). Likewise, the legacies of researchers foundational to soundscape studies like that of Schaeffer or Schafer still constitute an important source of inspiration for many sound artists[3] (e.g., see Hellström, 2011; Schütz, 2017; Vogel, 2013). In this light, sound artists seem particularly well-suited to bridge the academia-practice gap in soundscape research: they are no strangers to the soundscape approach, and are trained to propose practical solutions for (re)designing sound environments (Cobussen, 2023).

Nevertheless, the artistic perspective seems to have received scant attention in the last two decades of academic soundscape research, and in turn recent advancements in the soundscape field seem to hold minimal relevance for sound artists.

Hence, although there has been a growing focus on soundscape interventions, this has not translated into a rise in studies exploring the effects of sound installations. The literature reviews presented in this dissertation—see chapters 2 and 3 for general reviews on added sounds, and chapter 4 for a review on the soundscape effects of natural sounds—reveal that among the numerous studies investigating the effects of adding sounds to pre-existing environments, only a handful specifically address sound installations. Rather, the majority of these studies focus on natural sounds or generic music, with limited reflection on the sonic content itself or on its applicability. Conversely, there seems to have been

[3] This does not mean that Schafer's work has not been called into question in the sound art field. Specifically, his strong stance on the a priori quality of sound environments (e.g., the concept of high-fi versus low-fi sound environments) and his tendency to prioritize sound over other sensory modalities are often criticized (e.g., see Lacey, 2016; Schütz, 2017).

little attempt to provide sound artists with methods derived from soundscape research to inform the design of sound installations. Existing frameworks are mainly prescriptive, built on prior artistic experience (e.g., Klein, 2009; Lacey, 2016; Seay, 2014) or research on music perception (e.g., Rönnberg & Löwgren, 2021), but do not address the evaluation of public space users' auditory experience and how it can inform creation. According to Robson and colleagues (2023), "research that addresses the practical question of what artists do and how that might impact the experience of audiences is largely absent from sonic arts discourse" (p. 25). This can be illustrated by the small proportion of projects involving public experience evaluation in databases such as the Catalogue of Soundscape Interventions or the Interactive Sound Installation Database (Fraisse et al., 2021; Moshona et al., 2024). Even when audience feedback data is collected by sound artists, they tend to find it difficult to exploit it and are more inclined to act on feedback from peers and curators (Robson et al., 2023).

There are three potential reasons for these research gaps. First, and as Lacey (2019) notes, the two foundational trajectories of soundscape research—one rooted in engineering/planning and the other in humanities/art—have bifurcated over recent decades. Second, it seems that the focus in soundscape research is gradually shifting towards the engineering/planning approach, which is more data-driven and quantitative. This can be demonstrated with the recent standardization efforts, the growing interest in computational approaches for soundscape modeling (Botteldooren et al., 2023; Hou et al., 2023; Ooi et al., 2024), as well as the current prominence of engineering/planning journals in the field (Yang & Lu, 2022). Third, on sound artists' side, documenting the perceptual impact of a sound installation is not generally part of the artistic practice, although public reception and visitors' relationship to the work usually plays a pivotal role (see Robson et al., 2023). Similarly, sound artists may not document their work/process in scholarly journals/conferences, which makes such evaluations difficult to find in the literature. As Lacey (2019) pointed out, "creative practitioners are at their best in creating experiences, rather than collecting the data that will later prove the value of the experiences" (p. 7).

Whatever the cause, the (recent) lack of mutual interest between soundscape research and sound art seems counterproductive, not only because sound artists are trained to propose creative solution for (re)designing soundscapes but also considering the prevalence of sound art in existing soundscape interventions. For instance, sound installations occupy a prominent place in the few catalogs that list, albeit non-systematically, soundscape interventions (e.g., see Cerwén, 2021; The CSI Project Team, 2023). In light of all of this, we share Lacey (2019) and Cobussen's (2023) vision that we need to (re)merge the two lines of inquiry of historical soundscape research. Notably, we need to better understand the role sound installation art can play in urban soundscapes, and to provide artists with the means to incorporate soundscape research methods into their creative process.

1.4. Research questions and structure

The research described in this thesis seeks to address the research gaps introduced above, which were identified in the multidisciplinary reviews presented respectively in chapters 2, 3, and 4. The research gaps are formulated as follows:

1. Current research does not provide enough evidence to develop accurate hypotheses about the effect of sound installations on soundscape assessment.
2. There is no consensus on a methodology to inform the design of sound installations through soundscape evaluation.

The main research questions of this dissertation were directly related to these two research gaps:

1. *How do public space users evaluate everyday urban soundscapes in the presence of sound art? Specifically, how do public space users' soundscape evaluations vary for different sound art composition strategies?*
2. *How can soundscape evaluations inform the design of public space sound installations?*

Given the site-specificity and idiosyncrasy of sound installation art, addressing those questions required to explore sound installations during the creation process. In particular, developing a method derived from current soundscape research that is effective in evaluating and informing sound art in public spaces requires that it be meaningful and appropriate for sound artists. To do so, it was essential to work closely with sound artists through research-creation collaborations. Although the meaning of the term *research-creation* is contested and more generally refers to artistic or design research with a focus on the creative output (Léchot Hirt, 2015), we refer here to collaborations between creative practitioners (here, sound artists) and researchers to produce knowledge regarding the design and soundscape impact of sound installations. This involves for the artistic projects to be directly integrated into the research projects through what could be characterized as research *through* design, where there is an emphasis—from the researcher's stance—on the research objectives and knowledge production (Findeli, 2018; Frankel & Racine, 2010). More specifically, I do not position myself as a sound designer nor as a sound artist in this dissertation, but rather as a researcher in the interdisciplinary field of soundscape studies, working in close collaboration with sound artists to assess the soundscape impact of their work and, doing so, contributing to their creative process. Given that my background includes a double bachelor's degree in engineering science and musicology (Sorbonne Université), as well as a master's in sciences applied to music (ATIAM cursus, IRCAM), I was uniquely positioned to understand the artists' creative and musical process while studying their work through the prism of soundscape research. Otherwise, producing theoretical, methodological, or practical knowledge applicable beyond the individual artistic projects required examining a range of sound installations in different contexts. This was the main motivation to pursue this PhD in an international cotutelle between McGill University, Montreal, Canada and IRCAM, Paris, France, which resulted in three research-creation projects with different artists and researchers, in various public spaces—two in Montreal and one in Paris—and with different timelines.

Accordingly, the thesis consists of four publications—two peer-reviewed journal articles, one manuscript to be submitted (presented in chapters 2, 3 and 4 respectively), and one peer-reviewed conference paper (integrated into chapter 5 – Discussion). The first three publications report on studies relative to each research-creation project, while the fourth introduces a collaboration framework to inform the design of public space sound installation with soundscape evaluation. Each project is not focused on a single research question but rather brings its own set of answers to the main research questions in this thesis. To the first research question, evaluating different installations in various contexts allowed to identify specificities and commonalities in the way sound installation can affect a public space's soundscape, in relation to compositional and contextual factors. To the second question, the different methodologies investigated across the three studies (one in situ, two in laboratory settings) culminate in the research-creation collaboration framework.

Broadly speaking, the research conducted in this PhD can be viewed through the lens of the five main priorities in soundscape research recently identified by Aletta and Xiao (2018) across the field: the academia-practice gap, the applicability of the soundscape framework, multisensory interactions in soundscapes, relationships between soundscapes and behavior, and the integration of relevant technologies for soundscapes. This research specifically addresses the academia-practice gap, the applicability of the soundscape framework, and the use of relevant technologies. However, it does not delve into multisensory interactions or the relationships between soundscape and behavior (see the limitations in chapter 5). Of course, sound art alone will not suffice to address the academia-practice gap, but collaborating with sound artists should be seen as a complement to the current outreach efforts towards urban stakeholders. Specifically, the research-creation collaborations conducted in this PhD provide insights as to how curated sounds affect soundscapes, help understand how soundscape researchers could work with other stakeholders, and ultimately highlight the potential for sound installation art to benefit urban soundscape. Further discussed throughout the dissertation, the two remaining priorities are related to the academia-practice gap: specifically, to the current debates surrounding the way soundscape interventions should be evaluated in real-world applications, and how immersive technologies could be used for that purpose (Aletta & Xiao, 2018). In that matter, we investigated the relevance of mixed methods approaches for evaluating and comparing sound installations both in situ and in laboratory settings, combining surveys, acoustic measurements, and interviews. Further, we developed and validated a soundscape simulation tool for prototyping sound installations across two laboratory studies. Finally, the framework proposed in this dissertation addresses these research priorities through a set of guidelines and recommendations for the implementation of research-creation projects involving public space sound installations.

The structure of the thesis is briefly outlined below:

Chapter 2 (publication 1) presents the results of an in situ evaluation of four temporary sound installations that were deployed in the same urban public space: the Fleurs-de-Macadam square in Montreal. This was part of a greater research-creation collaboration project between the cross-sector partnership Sounds in the City, the City of Montreal, and sound design company Audiotopie.

Chapter 3 (publication 2) reports a laboratory study that was conducted at IRCAM, Paris as part of an ongoing research-creation collaboration with sound artist Nadine Schütz around her permanent sound installation *Niches Acoustiques* that will be deployed in the forecourt of the Judicial Court of Paris.

Chapter 4 (publication 3) covers another laboratory study that was conducted at CIRMMT, Montreal, also part of an ongoing research-creation collaboration investigating *Les Madelinéennes*, a permanent sound installation created by Charles Montambault in 2023 in the Parc des Madelinots, a small urban park in Montreal.

Chapter 5 is a comprehensive scholarly discussion of all the theoretical, methodological, and practical findings generated by this research. It also introduces a research-creation collaboration framework for designing and evaluating public space sound installations **(publication 4)**.

Chapter 6 shortly summarizes the contributions of this research and their implications for future soundscape research.

CHAPTER 2. SHAPING CITY SOUNDSCAPES: IN SITU COMPARISON OF FOUR SOUND INSTALLATIONS IN AN URBAN PUBLIC SPACE[4]

Abstract

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

[4] This chapter is a version of Fraisse, V., Tarlao, C., & Guastavino, C. (2024). Shaping city soundscapes: In situ comparison of four sound installations in an urban public space. *Landscape and Urban Planning*, 251, 105173.

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.

2.1. 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, 2016b). 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). 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* (Fraisse, Schütz, et al., 2024; Oberman et al., 2020). 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 remain 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 12913-2, 2018; ISO TS 12913-3, 2019). 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 (*pleasantness* 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, 2019; Fraisse, Steele, et al., 2020; Steele, Legast, et al., 2019), while a description of the research-creation collaboration is available in (Guastavino et al., 2022a). 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 (Fraisse, Schütz, et al., 2024). 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.

2.2. Method

2.2.1. Public space designs

Initially a vacant lot, the Fleurs-de-Macadam square underwent three prototype designs (see Figure 2.1 and Figure 2.2) 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 Figure 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 Figure 2.3).

2.2.2. Sound installations

Four sound installations were developed by the artist collective Audiotopie to resonate with the purposes of the different designs[5]. Each installation was deployed for a portion of the full design duration (roughly two to three weeks out of six, see Figure 2.3). Throughout their deployment periods (colored boxes in *Figure 2.3*), the sound installations were on during the day from 9am to 11pm. 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., 2022a). 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).

[5] Excerpts for each installation are available in https://soundscape-intervention.org/ex-place-des-fleurs-de-macadam/

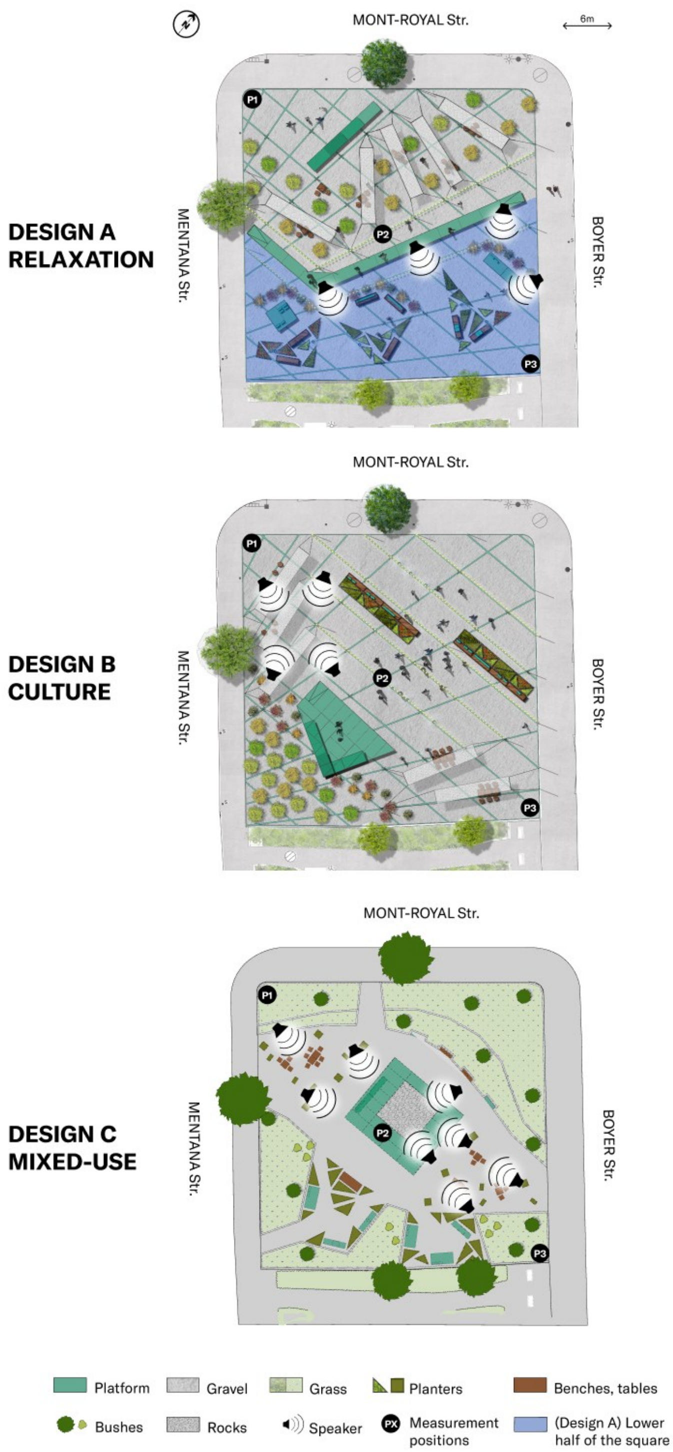


Figure 2.1. Map of the studied site, showing each of the design layouts (Design A and B: 2018; Design C: 2019), as well as measurements and speaker positions. Maps for designs A and B provided by design firm Castor et Pollux and used and edited with permission.

Figure 2.2. Photographs of each space design with sound installations. Speakers are enclosed in white cylindric boxes attached on poles. Pictures: Audiotopie for Designs A and B; Valérian Fraisse for Design C.

In 2018, two separate four-speaker installations were deployed with different spatial layouts for Designs A and B (see Figure 2.3). 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 Figure 2.1). 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. 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 Figure 2.1). For the second sound installation – Voices – speakers were positioned in a space around a seating area (Figure 2.1). 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. Composed by Simone D’Ambrosio, the third and fourth sound installations – Synthesizers and Seascape, respectively – were in place for two weeks each in the summer 2019 over Design C, both using the same configuration of eight speakers along the diagonal of the space (see Figure 2.1 and Figure 2.3). 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. 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.

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).

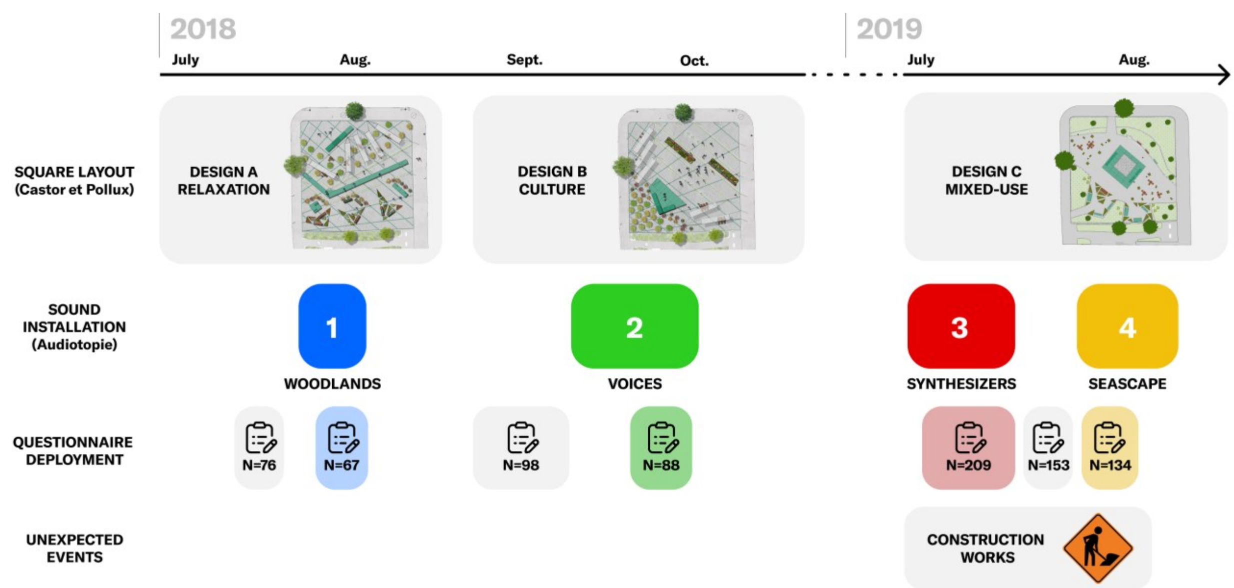


Figure 2.3. Timeline of the project, including duration of installation for the space layouts, the sound installations, the data collection periods and associated sample sizes, and the presence of construction work in the summer 2019.

2.2.3. Sound level measurements

We performed an acoustic characterization of the park through $L_{Aeq,10min}$ 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 Figure 1), covering weekdays and weekends (see Fraisse, 2019; 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).

2.2.4. Soundscape assessments

2.2.4.1. 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 2.1), 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 2.1) 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.

Topic	Question - EN	Question - FR	Label	Conditions tested
SSQP – PAQS (Likert scales)	I find this soundscape to be:	Je trouve l'ambiance sonore en ce lieu :		
	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
	Eventful	Animée	Eventful	A, B, C
Appropriate (Likert scale)	Appropriate for my activity	Appropriée pour mon activité	Appropriate	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)	Please list below the sounds/noises that you are hearing around you into the column that applies.	Listez ci-dessous les sons et bruits que vous entendez dans ce lieu en ce moment, dans la colonne correspondante.		
	Pleasant	Agréable	Pleasant sources	A, B, C
	Unpleasant	Désagréable	Unpleasant sources	A, B, C
	Neutral	Neutre	Neutral sources	A, B, C

Table 2.1. Questionnaire instrument: main variables.

2.2.4.2. 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 Figure 2.3), 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).

2.2.5. Data processing and analysis

2.2.5.1. 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 were 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 Benjamini-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).

2.2.5.2. 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).

2.3. Results

2.3.1. 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 Figure 2.4. 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 Figure 2.4).

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 (Figure 2.5), 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 (*Figure 2.5*), 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.

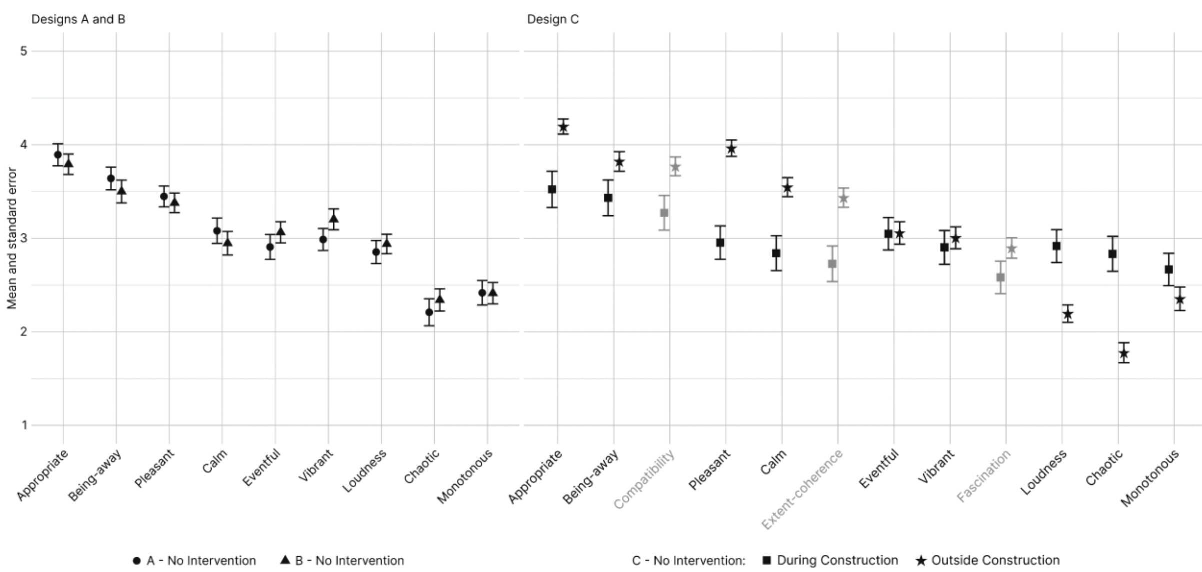


Figure 2.4. Mean soundscape ratings and standard errors, collapsed over all participants for each space design, without sound installations. Left: Designs A (N=76) and B (N=98). Right: Design C during Construction (N=44) and outside Construction (N=109). Scales only used for Design C are shown in grey.

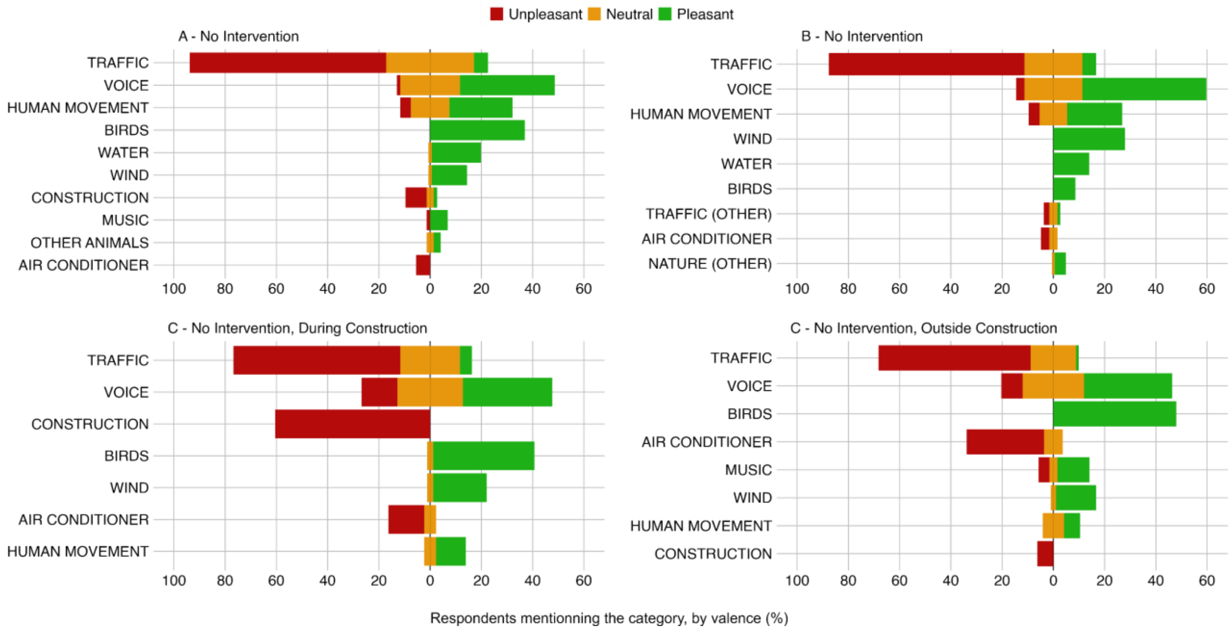


Figure 2.5. Proportions of sound sources mentioned by category and valence, collapsed over all participants for each space design, without sound installations. Top: Designs A (N=73) and B (N=93). Bottom: Design C during Construction (N=43) and outside Construction (N=96). Only sound sources mentioned by more than 5% of respondents are included. Sources are sorted from most to least frequently mentioned.

2.3.2. 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 *Figure 2.3*) 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).

2.3.3. DESIGN A: Woodlands installation

2.3.3.1. 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 ≈ 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 ≈ 26.2, $p \approx 0.034$). According to follow-up Mann Whitney U tests (see Table A.2 and Figure 2.6) 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.

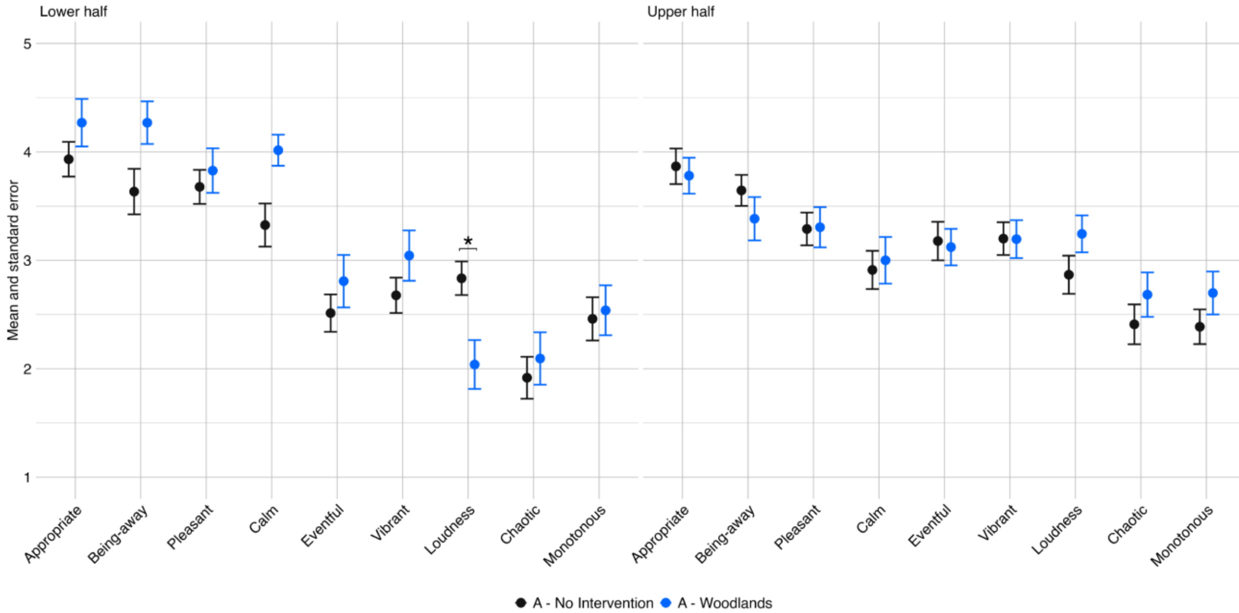


*Figure 2.6. Design A: Mean soundscape ratings with and without the Woodlands sound installation for both sides of the space in Design A (Upper half: N=86; Lower half: N=57). *, p < .05 (after applying Benjamini-Hochberg adjustment).*

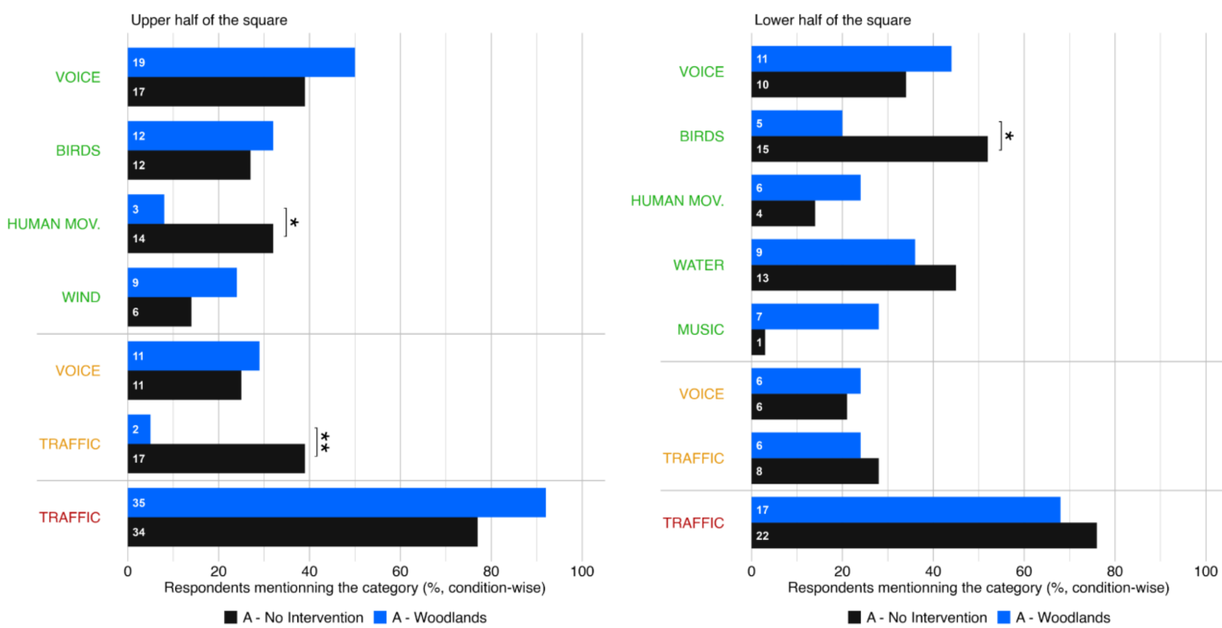


*Figure 2.7. Design A: Proportions of sound source categories (N=136). Categories in green were reported as pleasant, in orange as neutral, and in red as unpleasant. Numbers inside the bars indicate the number of respondents. Music mentions were not included in the regressions due to low EPV. *, p < .05; **, p < .01.*

2.3.3.2. 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 (Figure 2.7).

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 (Figure 2.7).

2.3.4. DESIGN B: Voices installation

2.3.4.1. Effect on soundscape ratings

A MANOVA on Design B reveals a significant effect of the Voices sound installation on soundscape evaluation (MATS ≈ 28.1, $p \approx 0.012$). Follow-up Mann Whitney U tests (see Table A.2 and Figure 2.8) 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 ($p \approx 0.0245$, $r \approx 0.20$).

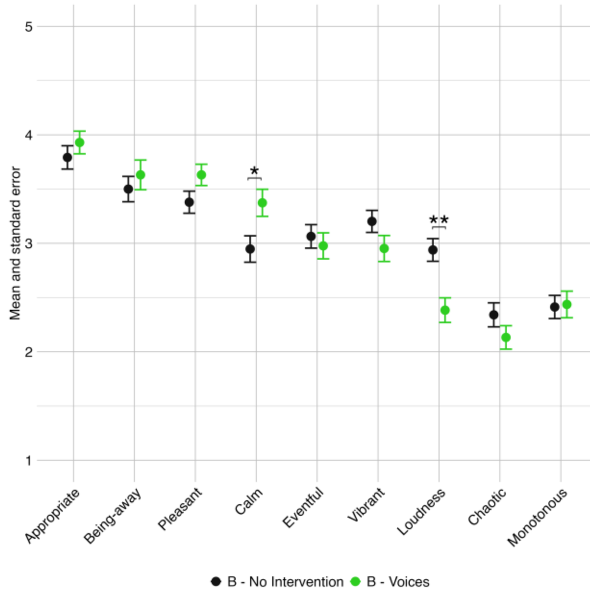


*Figure 2.8. Design B: Mean soundscape ratings with and without the Voices sound installation (N=186). *, p < .05; **, p < .01 (after applying Benjamini-Hochberg adjustment).*

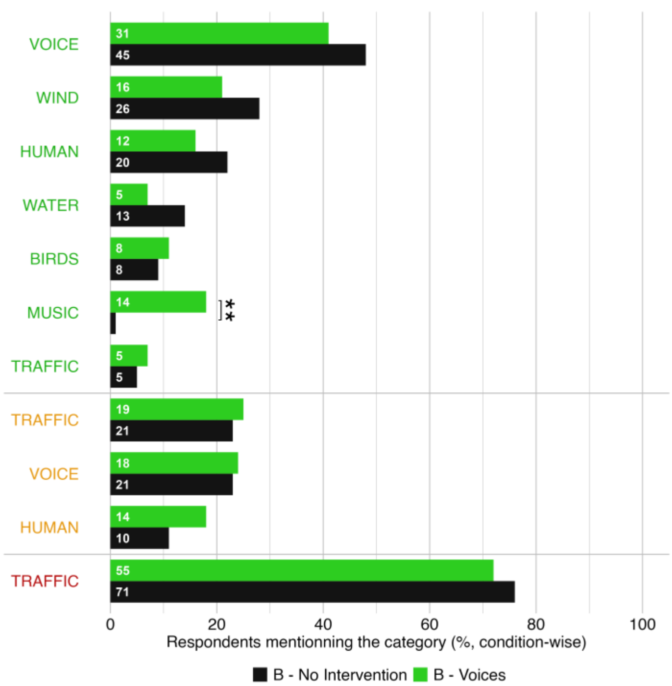


*Figure 2.9. Design B: Proportion of sound source categories (N=169). Categories in green were reported as pleasant, in orange as neutral, and in red as unpleasant. Numbers inside the bars indicate the number of respondents. *, p < .05; **, p < .01*

2.3.4.2. 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 (Figure 2.9).

2.3.5. DESIGN C: Synthesizers and seascape installations

2.3.5.1. 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 ≈ 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 Figure 2.10) 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.

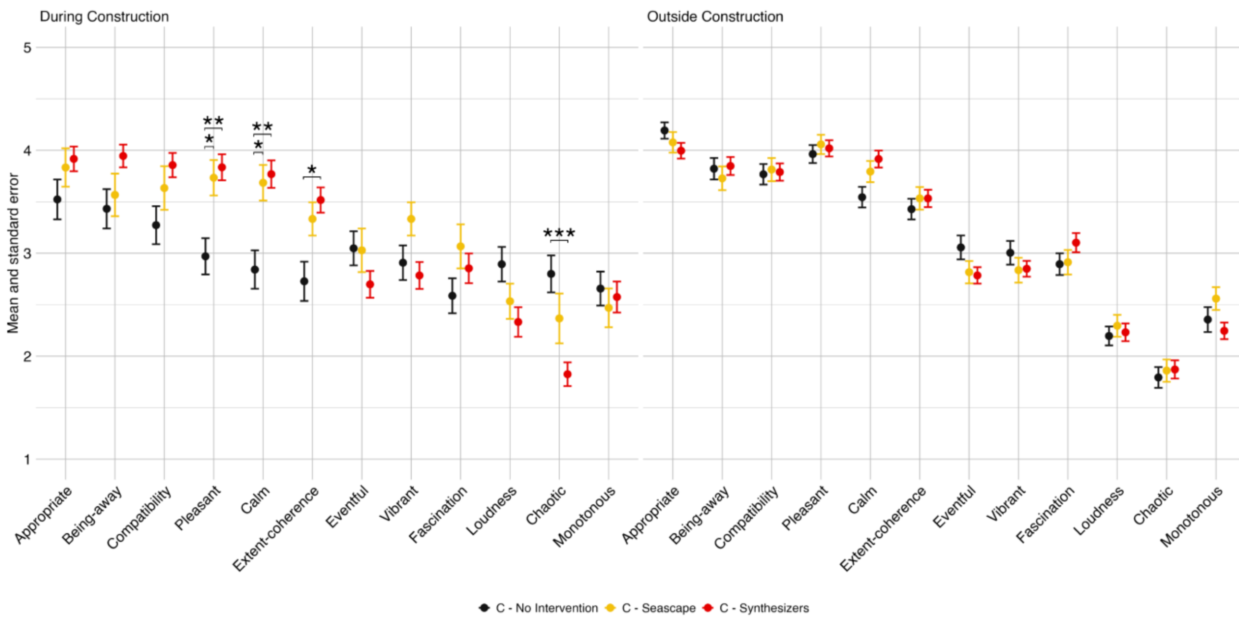


*Figure 2.10. Design C: Mean soundscape ratings with and without the Seascape and Synthesizers sound installations, during and outside construction time (During Construction: N=135; Outside Construction: N=361). *, p < .05; **, p < .01; ***, p < .001 (after applying Benjamini-Hochberg adjustment).*

2.3.5.2. 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 Figure 2.11).

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 Figure 2.11). 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 Figure 2.11).

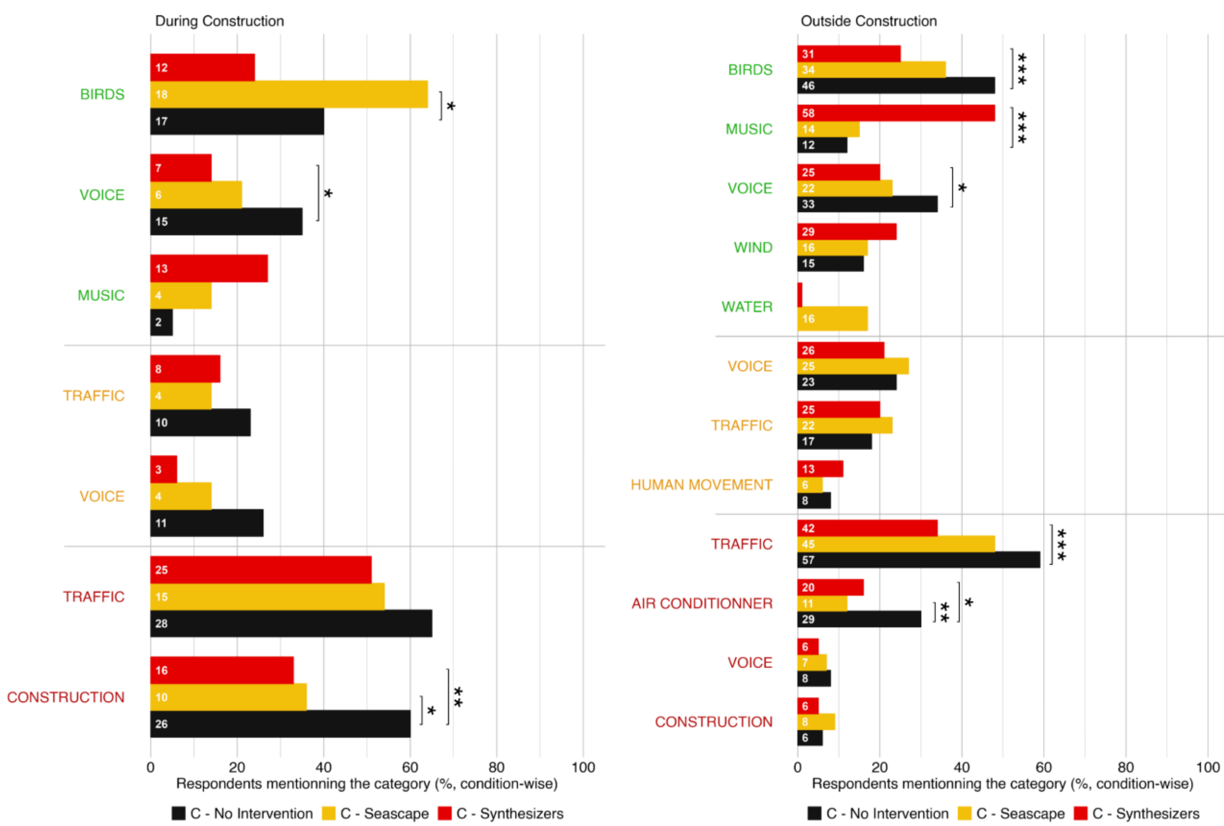


*Figure 2.11. Design C: Proportion of sound source categories (N=432). Categories in green were reported as pleasant, in orange as neutral, and in red as unpleasant. Numbers inside the bars indicate the number of respondents. Water mentions outside construction and music mentions during construction were not included in the regressions due to low EPV. *, p < .05; **, p < .01; ***, p< .001.*

2.4. 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.

2.4.1. 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 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, 2016b). 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).

2.4.2. 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).

2.4.3. 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, Steele, 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.

2.5. 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.

2.6. Transition

This chapter investigated the in situ soundscape experience of public space users in the presence of four temporary sound installations. The unique opportunity to carry out a systematic field evaluation of the soundscape interventions was made possible thanks to the research partnership between Sounds in the City, the City of Montreal, and the sound design company Audiotopie. Although data collection occurred prior to the beginning of this thesis (see the preliminary results in Fraisse, 2019; Fraisse et al., 2020; Steele et al., 2019), this chapter offers a thorough reanalysis of the data, including a systematic comparison of all four installations and an analysis of sound source listings in relation to temporal and spatial context. The findings provided valuable insights into the way sound art affects public space soundscape and how sound installations should be evaluated in situ.

Following this study, we realized that laboratory evaluations would be necessary to complement our theoretical findings and to further develop a methodology for guiding sound installation design before deployment. In situ evaluations, while providing the most ecologically valid results, suffer from low experimental control, limiting the ability to conduct detailed analyses of the relationship between composition strategies and their impact on soundscape. Additionally, in situ prototyping must adhere to site-specific constraints. In contrast, laboratory settings offer finer control over conditions, allowing the artist to freely explore and predict the impact of various composition strategies relevant to their artistic projects. Specifically, these settings enable the investigation of distinct and elementary composition elements or what could be called “building blocks” of the installation to be deployed. Overall, examining the role of laboratory prototyping was crucial for developing a research-creation collaboration framework suitable for designing and evaluating public space sound installations, which will be outlined in chapter 5.

Complementing the insights gained from this study, the next two chapters will focus on two research-creation projects involving the laboratory evaluation of two permanent public space installations: *Niches Acoustiques*, by Nadine Schütz, in Paris (chapter 3) and *Les Madelinéennes*, by Charles Montambault, in Montreal (chapter 4).

CHAPTER 3. USING SOUNDSCAPE SIMULATION TO EVALUATE COMPOSITIONS FOR A PUBLIC SPACE SOUND INSTALLATION[6]

Abstract

While urban sound management often focuses on sound as a nuisance, soundscape research suggests that proactive design approaches involving sound art installations can enhance public space experience. Nevertheless, there is no consensus on a methodology to inform the composition of sound installations through soundscape evaluation, and little research on the effect of composition strategies on soundscape evaluation. The present study is part of a research-creation collaboration around the design of a permanent sound installation in an urban public space in Paris (*Niches Acoustiques* by Nadine Schütz). We report on a laboratory study involving the evaluation of composition sketches prior to the deployment of the installation on-site. Participants familiar with the public space (N=20) were exposed to Higher-Order Ambisonics recordings (HOA) of the site, to which compositions of the sound installation pertaining to different composition strategies were added using a soundscape simulation tool. We found three principal components relevant for evaluating and comparing sound installation sketches:

---

[6] This chapter is a version of Fraisse, V., Schütz, N., Wanderley, M. M., Guastavino, C., & Misdariis, N. (In press). Using Soundscape Simulation to Evaluate Compositions for a Public Space Sound Installation. *Journal of the Acoustical Society of America*, 156(2), 1183-1201.

pleasantness, familiarity and variety. Further, all composition sketches had a significant effect on the soundscape's familiarity and variety, and the effect of the compositions on these two components was stronger when composition strategies involved abstract sounds (sounds which were not clearly identifiable).

3.1. Introduction

In urban planning, sound is often considered as an environmental burden that should be mitigated. To address the deleterious effect noise exposure has on public health (World Health Organization, 2011), most environmental policies focus on noise control procedures (e.g., Steele et al., 2023; Trudeau et al., 2018). Yet, sound plays a complex role in the way cities are experienced, and reducing sound levels alone does not necessarily lead to an improved quality of life (Kang, 2006; Kang & Schulte-Fortkamp, 2015). Rather than being seen as a nuisance that has to be mitigated, sound can instead be considered as a resource in relation to other urban planning considerations, through the soundscape approach (Kang et al., 2016). Soundscape (defined by the International Standard Organization (ISO) as the "acoustic environment as perceived or experienced and/or understood by a person or people, in context" (ISO TS 12913-1, 2014) enables more complex representations of sound and allows to envisage both the positive and negative outcomes it can have on the quality of urban environments (Dubois et al., 2006).

In this regard, a growing body of literature has focused on implementing and documenting design plans to preserve or improve existing soundscapes through soundscape interventions (Fiebig & Schulte-Fortkamp, 2023; C. Moshona et al., 2022). Specifically, there is increasing evidence that the deliberate introduction of new sound elements to existing acoustic environments can benefit urban public spaces. Some of these studies demonstrated that added sounds could positively affect people's behavior, for instance by fostering social interactions (Adhitya & Scott, 2018; Bild, Steele, et al., 2016; Franinovic & Visell, 2007; Hellström, 2011), increasing duration of stay and favor activities such as chatting or eating/drinking (Aletta, Lepore, et al., 2016; Lepore et al., 2016), and even by affecting walking pace (Easteal et al., 2014; Lavia et al., 2016) or crowd density and walking patterns (Meng et al., 2018). Other field studies showed that added sounds can improve soundscape evaluation, through global assessments (Cerwén, 2016; De Pessemier et al., 2022) or by increasing evaluations on variables such as *eventfulness* and *excitement* (Jambrošić et al., 2013), *pleasantness* (Steele et al., 2021), *calmness* (Fraisse et al., 2020) or even by reducing the perceived sound level (Steele, Legast, et al., 2019). In laboratory settings, the effects of adding natural sounds such as birds or streams on soundscape evaluation have been extensively investigated, studies showing for instance that such sounds could be evaluated as preferable (Jeon et al., 2010), reduce perceived loudness and increase *pleasantness* (J. Y. Hong, Ong, et al., 2020), increase soundscape quality (Ong et al., 2019) and *eventfulness* (Lugten et al., 2018). Otherwise, a recent study by Oberman and colleagues evaluated the impact of three sound art interventions on soundscape measurement and showed different impacts for each intervention on perceived *pleasantness*, *calmness*, *excitement* and *appropriateness* (Oberman et al., 2020).

A broad range of methods have been used to evaluate the perceptual and affective attributes of soundscape interventions. Among them, soundscape scales have been widely spread and refined in recent years. The most broadly used protocol is the Swedish Soundscape Quality Protocol (SSQP) (Axelsson et al., 2012), featured as the method A in the ISO/TS 12913-2:2018 (ISO TS 12913-2, 2018). It comprises a set of scales based on principal components underlying soundscape evaluation, *pleasantness* and *eventfulness*, established by Axelsson et al. (Aletta, Kang, et al., 2016). The method proposed in the standard also includes a scale relative to *appropriateness* (ISO TS 12913-2, 2018). Otherwise, Payne and Guastavino proposed the Perceived Restorativeness Soundscape Scale (PRSS) to assess the restorative potential of sound environments in terms of *being-away*, *extent-coherence*, *compatibility* and *fascination* (Payne, 2013), while Welch et al. developed a set of seventeen semantic differentials to measure the affective properties and the qualities of soundscape, though a study involving creative writing (Welch et al., 2019). The use of both the SSQP and the PRSS led to statistically significant results when evaluating or comparing sound art interventions (e.g., Oberman et al., 2020; Steele et al., 2019, 2021). However, the study led by Oberman and colleagues showed that the SSQP alone could provide ambiguous responses regarding the impact of sound interventions on the *eventfulness* component and could be optimized (Oberman et al., 2020). If soundscape scales provide a subjective evaluation of soundscape among a set of predetermined criteria, more in-depth information about the various associations, emotions and feelings associated with the perception of sound environments in the presence of sound art can be obtained through qualitative methods such as ethnographical research (e.g., Lacey et al., 2019) or open-ended interviews (e.g., Bild et al., 2016). Ultimately, quantitative and qualitative data collection methods can be integrated together through methodological triangulation (ISO TS 12913-2, 2018; ISO TS 12913-3, 2019).

To collect soundscape data, laboratory and in-situ methods coexist, each having their own advantages and limitations (Aletta, Kang, et al., 2016). Laboratory experiments involve the simulation or reproduction of soundscapes and provide more control on the sound environment. Among the existing soundscape reproduction or simulation techniques, Ambisonics (see Moreau, 2006) has been increasingly used in the recent years and is usually considered ecologically valid (Davies et al., 2014; Guastavino et al., 2005; Tarlao et al., 2022). Generally, studies involving the simulation of soundscape interventions artificially integrate added sounds to a pre-recorded sound environment (J. Y. Hong, Ong, et al., 2020; Jeon et al., 2010; Lugten et al., 2018; Ong et al., 2019), and similar technologies have been proposed as soundscape simulation tools to help professionals of the built environment anticipate the impact of urban design decisions on soundscape (Tarlao, Steele, et al., 2023; Yanaky et al., 2023), or as a tool for soundscape composition (Sarwono et al., 2022). Still, the only laboratory study evaluating the impact of sound art interventions on soundscape recorded them *in situ* and compared them with recording positions in which they were not audible through a virtual soundwalk approach (Oberman et al., 2020).

Overall, studies on the impact of added sounds on soundscape mostly focus on the introduction of either natural sounds or generic music to existing sound environments, and the few studies on the impact of sound art installations on soundscape (Fraisse, Steele, et al., 2020; Hellstrom et al., 2014; Hellström, 2011; Jambrošić et al., 2013; Lacey et al., 2019; Oberman et al., 2020; Steele, Legast, et al., 2019) were systematically carried out *a posteriori* i.e. once the sound installations were already deployed. If such studies revealed the potential for sound art to improve urban soundscapes, the methods used provide little room for sound artists to implement perceptual feedback within the compositional process. Yet, people's reception and perception has been an essential consideration for sound artists from the very emergence of sound installation art (see Guastavino et al., 2021 for a review). Similar to the way soundscape researchers emphasize context (Herranz-Pascual et al., 2010; ISO TS 12913-1, 2014), the design of public space sound installations is usually thought of in relation to a multitude of site-specific aspects, including perception (e.g. Tittel, 2009; Vogel, 2013). Hence, evaluating sound installations' impact on soundscape before deployment through soundscape simulation would benefit sound artists by informing their composition at the early stages of creation process.

The relationship between a sound installation and its existing environment can take many forms, depending on the artistic intention and on site-specific considerations. Through this variety, common composition strategies and issues have been theorized in the literature (see Guastavino et al., 2021). Livingston proposed a taxonomic division between strategies for adding sounds in public spaces: *integrated / site-specific / background* (added sounds that subtly blend in with the existing sound environment so that they can stay unnoticeable) versus *oppositional / borrowed / foreground* (added sounds that are clearly noticeable, see [Livingston, 2016]). Similarly, Botteldooren et al. proposed three design imperatives for soundscape design: *backgrounded* (the introduced sounds stay unnoticed), *supportive* (the added sounds enhance the existing experience) and *focused* (the added sounds become a point of interest, see Kang & Schulte-Fortkamp, 2015). Many creators also investigated the notion of *non-energetic masking* (also called *informational masking*) where added sounds purposely distract listeners' attentions from other sources (Anderson, 2008; Hellstrom et al., 2014; Lacey et al., 2019; Rudi, 2005; Torehammar & Hellström, 2012), and the phenomena has also been studied in the soundscape literature (e.g., Hong et al., 2020; Licitra et al., 2010; Oberman et al., 2020). The existence of shared composition strategies does not imply that there is an obvious way to operationalize them, and approaches can be as diverse as there are sound artists (for instance, see how two approaches to generate *oppositional* sounds may differ in [Anderson, 2008] and [Torehammar & Hellström, 2012]). Nevertheless, recent works showed that different artistic propositions could lead to different perceptual impacts on soundscape (Oberman et al., 2020; Steele, Legast, et al., 2019), and further work is needed to better understand the link between sound art composition strategies and their impact on soundscape.

The present study was conducted in the context of a research-creation collaboration between the authors of this paper around the permanent sound art installation *Niches Acoustiques*. Created by sound artist Nadine Schütz (the other authors are researchers in the fields of soundscape, music technology and sound design), this laureate project of *Budget Participatif de la Ville de Paris* will lead to the planned, permanent deployment of the sound installation on the forecourt of the new Judicial Court of Paris, France. The overall intention of *Niches Acoustiques* is to create an appeasing, beneficial, and varied auditory foreground which reduces the perceived dominance of annoying and monotonous noises while opening up the courthouse's forecourt to an urban narrative which connects it to the urban neighborhood. The title of the installation, *Niches Acoustiques*, is borrowed from the bioacoustics Niche Hypothesis, according to which the co-existence of diverse species, particularly in densely populated areas, is fostered by the spectral and temporal differentiation of their vocalization patterns (Farina, 2013; Krause, 1993). The 'Acoustic Niches' sound installation project interprets, activates and transposes this principle in a (psychoacoustically informed) spectrotemporal means to modify soundscape perception by adding distinct sonic ambiences on the forecourt, in a non-intrusive way, with low volumes of the added sounds, and through a 'complementary composition' approach. In this context, the notion of auditory foreground refers to added sounds which are acoustically, semantically, and/or spatially distinct from the pre-existing sound environment. The collaboration (including the present study) aims at informing the composition of *Niches Acoustiques* and evaluating the impact of the sound art intervention through soundscape evaluations at different stages of the composition process. We report here on a laboratory study involving the simulation of compositional sketches of the sound installation (in the form of short excerpts) in presence of a reproduction of the forecourt's existing sound environment using a soundscape simulation tool developed and validated in a previous study (Fraisse, Schütz, et al., 2022). To compare the impact of the different sound installation sketches on soundscape evaluation, participants familiar with the forecourt of the Judicial Court were invited to evaluate each excerpt with a set of semantic differential scales and were then asked to respond to a semi-structured interview. The present study addresses the following research questions:

RQ1: How do public space users evaluate everyday city soundscape modified by the presence of sound art?

RQ2: How do public space users' soundscape evaluations vary for different sound art composition strategies?

Considering that the composition of a sound installation is highly sensitive to site-specific considerations as well as to its artistic intention, answering the second research question required to provide a classification of composition strategies that can be generalized to other sound art interventions. To do so, the methodology applied by the sound artist during the creation of the sound installation sketches was structured so that they could be gathered into broader composition strategies, and we report here on the impact of these composition strategies on soundscape rather than on an excerpt-to-excerpt analysis. To allow for their comparison, these strategies were subsequently positioned within an *Abstract* (sounds that can't be ascribed to any real or imagined provenance) / *Referential* (recorded sounds that suggest or at least do not hide the source to which they belong) dichotomy, as proposed by Leigh Landy (*About the ElectroAcoustic Resource Site Project*, 2023; Landy, 2007). Our intuition, prior to the experiment, was that Abstract sounds would be perceived as being more *oppositional* because of their unexpected nature while Referential sounds would be perceived as being more *integrated* because they could more easily blend in with the existing sound environment.

To wrap up, the goal of this study is not to impose compositional principles to sound artists or to replace the artistic intention—each sound installation having its own artistic statement and design goals—, but rather to systematically evaluate the impact of sound art composition strategies that are broad enough to be transferred to other sound art interventions. The present study also aims at investigating the productivity of the proposed research-creation methodology, specifically assessing the relevance of the soundscape simulation tool for evaluating sound art interventions. Meanwhile, the proposed methodology is intended to help inform the design of Nadine Schütz's *Niches Acoustiques* sound installation by anticipating its impact on soundscape evaluation.

3.2. Methods

3.2.1. Soundscape simulation tool

The present study uses a soundscape simulation tool previously developed and validated through listening tests. Information about the tool development and validation is presented in (Fraisse, Schütz, et al., 2022). The simulation consists of the reproduction of Higher-Order Ambisonics (HOA) field recordings of the **sound environment** on site, along with the auralization of **added sounds**, yielding composition sketches of the sound installation using a 3D acoustic model of the site (simulating early reflections and late reverberation) converted to HOA streams. The resulting soundscape is presented over a loudspeaker array in a listening room for **soundscape evaluation** using semantic differential scales (Figure 3.1). All components of the simulation, from HOA encoding and auralization to playback and graphical user interface are implemented in Cycling '74 Max (*What Is Max?*, 2023).

3.2.1.1. Measurement campaign

The data on the sound environment of the Judicial Court of Paris' forecourt was collected during a measurement campaign in spring 2021, detailed in Fraisse, Nicolas, et al. (2022) and Fraisse, Schütz, et al. (2022). We conducted punctual HOA recordings and sound level measurements throughout the public space across five sessions covering different activity levels (weekday morning, afternoon and evening; weekend morning and evening). During each session, 5-minute recordings were made across measurement points gridding the square (Figure 3.2). At each position, we measured equivalent sound pressure and third-octave levels with a B&K 2250 sound level meter together with 4^{th}-order ambisonics recordings with an mh Acoustics em32 Eigenmike (*Brüel & Kjær*, 2023;

Mhacoustics, 2023; Moreau, 2006). All measurements were oriented towards the direction opposite to the Judicial Court, at a height of 1.3m.

3.2.1.2. Baseline sound environment

The listening test focuses on the comparison of various sound installation sketches. To ensure smooth transitions between these conditions, we designed a continuous baseline sound environment by concatenating 4^{th} order HOA separate excerpts from the measurement campaign (not to be confused with the Referential excerpts presented in Section 3.2.2). The excerpts were selected to ensure that they were representative of the public space's average level of activity, spatially close enough to each other (see the included positions in *Figure 3.2*), and did not contain salient sounds so that participants focus on the added sounds during the listening tests (see Fraisse, Schütz, et al. [2022] for more detail). Excerpts, selected during joint listening sessions with two of the authors, ranged from 30 seconds to around 2 minutes. A total of 38 excerpts were crossfaded in fully random orders using Python's reathon library to generate Reaper scripts (Reathon, 2023). In other words, a Baseline using the same 38 excerpts was generated with a different, randomized order for each participant so that they would listen to a different superposition of the background recordings and the added sounds, and to ensure that the observed effects would be independent of the temporal evolution of the background sound environment. A 3-second crossfade between excerpts was applied to provide short yet smooth and unnoticeable transitions. In total, the Baseline lasted around 45 minutes, and was looped in the experiment. A 40-minutes sound level measurement of the calibrated Baseline (without the 4 dB padding mentioned Section 3.2.1.5) was conducted in the listening room using a B&K 2250. We found a $L_{Aeq,40min}$ of 61.9 dBA and a L_{A10}-L_{A90} of roughly 6 dBA, confirming that the chosen excerpts were representative of an average level of activity in the parvis while remaining sufficiently stable (Fraisse, Nicolas, et al., 2022).

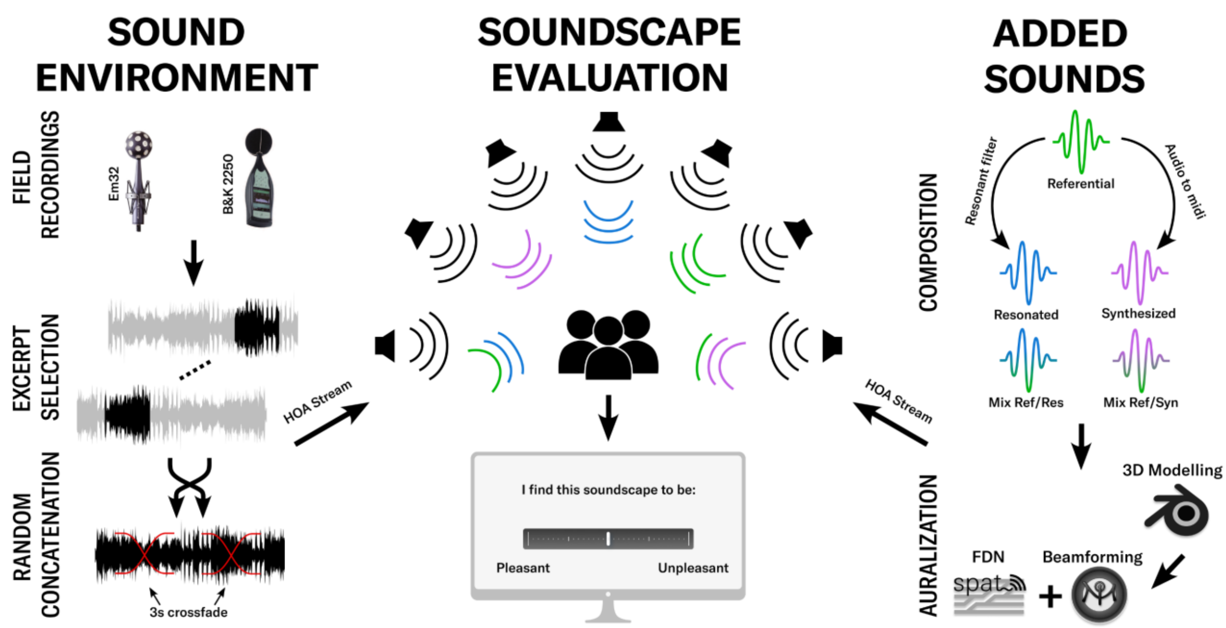


*Figure 3.1. Flowchart of the soundscape simulation tool. The **sound environment** (left) is simulated from HOA excerpts. Monophonic composition sketches of the sound installation in the form of composed **added sounds** are auralized with a 3D modelling of the space (right). HOA streams are fed into a listening room for **soundscape evaluation**.*

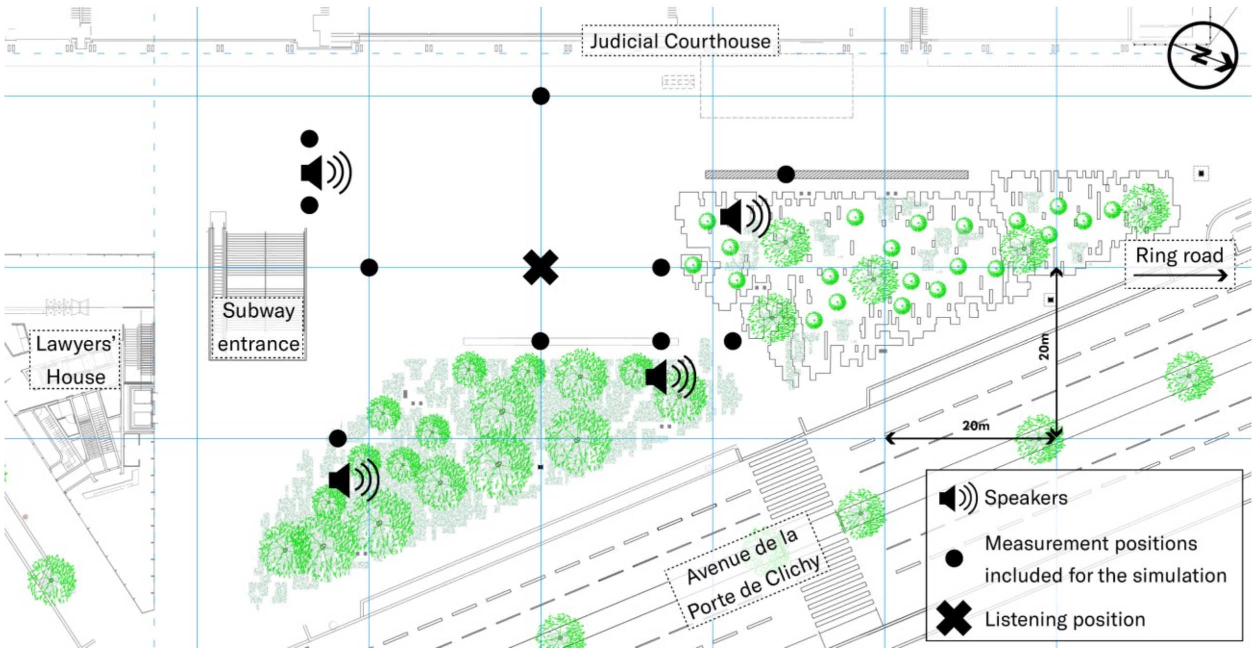


Figure 3.2. Map of the forecourt in front of the Judicial Court of Paris. The Niche Acoustiques' installation speakers will be mounted on four lighting poles across the forecourt. Punctual HOA recordings and sound level measurements were made across 18 measurement points, of which 11 were included for the soundscape simulation. The simulated listening position is at the center of the space.

3.2.1.3. Added sounds auralization

The auralization method is only summarized here, a complete description of the procedure is available in Fraisse, Schütz, et al., (2022). Initially in the form of monophonic excerpts, the added sounds were spatialized using IRCAM's EVERTims framework (Poirier-Quinot et al., 2017) integrated in Max's spat~ library (Spat | Ircam Forum, 2023). The 3D model of the forecourt from which the auralization is based on includes the main surfaces of the forecourt, the position of the sound sources (the future sound installation's speakers), as well as of the listener (see *Figure 3.2*). Upon reception of the 3D model, EVERTims computes a list of image sources that correspond to the early reflections of the space, while the late reverberation is simulated with a Feedback Delay

Network (Poirier-Quinot et al., 2017; Schroeder, 1962). The output of the auralization unit is ultimately encoded into 4th order HOA streams with spat~ (Moreau, 2006). As physical parameters such as the reverberation time of the court were missing, we fine-tuned the auralization through analytical listening with sound experts, and validated it in a preliminary listening test, as reported in Fraisse, Schütz, et al. (2022). Finally, the mastering of the auralized added sounds was operated in two steps. First, all excerpts' loudness was normalized with pyloudnorm, a Python implementation of ITU-R BS.1770-4 standard for loudness measurement (Steinmetz & Reiss, 2021). Then, the gain was adjusted by ear in presence of the simulated sound environment for each of the excerpts by the second author through a dedicated Max patch, to mimic the protocol that will be carried out during the sound installation's deployment.

3.2.1.4. Ambisonics reproduction

The experiment was conducted at IRCAM's studio 4, an acoustically-treated listening room, over a hemispherical dome of 24 Amadeus PMX 4 speakers (Amadeus | PMX 4, 2023) placed on four height levels beginning at ear level (Figure 3.3). Encoding and decoding parameters were chosen during joint listening sessions including three of the authors, who compared *in situ* listening with the reproduced sound environment. The Eigenmike 32 signals were encoded into a 4^{th}-order HOA stream with spat~ using Tikhonov regularization (Moreau, 2006). At the output of the system, the auralized added sounds and the sound environment—both in the form of 4^{th}-order HOA streams—were summed and decoded with spat~ using energy preserving method with $max\text{-}r_E$ weighting function (Zotter et al., 2012).

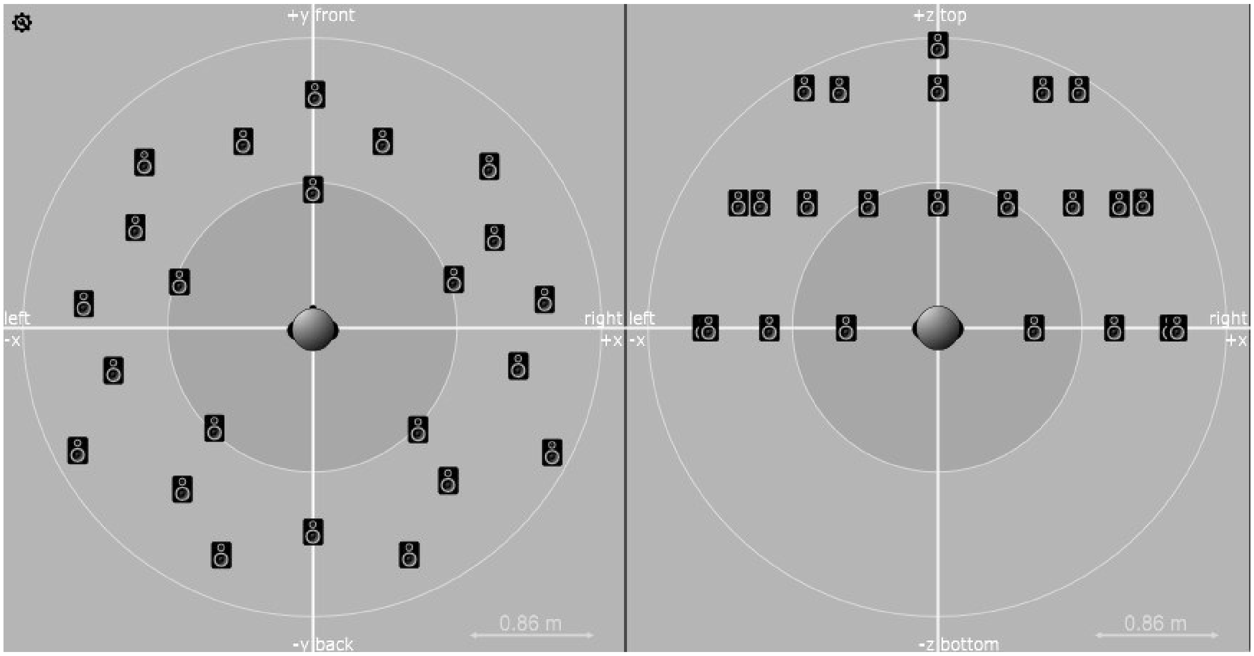


Figure 3.3. Diagram of the loudspeaker array with simplified head for orientation from spat~. Left: from the top; right: from behind.

3.2.1.5. Sound level calibration of the baseline sound environment

The 5-minute A-weighted equivalent levels (L_{Aeq}) values captured during the measurement campaign were compared with similar measurements in the listening room's sweet spot at a height of 1.3 m to calibrate the reproduction levels of the baseline sound environment (Brüel & Kjær, 2023). However, we decided to reduce the reproduced soundscape sound level by 4 dB with respect to *in situ* measurements, as the level of the reproduced soundscape was perceived by the authors as higher than *in situ*. Observed in several laboratory studies (e.g., Cadena et al., 2017; Oberman et al., 2020; Sudarsono et al., 2016), this phenomenon could be related to the relatively high sound levels *in situ*, with 5-minute L_{Aeq} typically ranging from 60 to 70 dBA (Fraisse, Nicolas, et al., 2022). A 4-dB reduction was unanimously perceived as the best match to replicate the perceived loudness *in situ*.

3.2.2. Added sounds composition

The artistic design goals of the sound installation have been presented in the introduction. This section focuses on the composition strategies for the sketches (i.e. the sound installation's sound materials) evaluated in the present study. The primary sound content of the new auditory foreground introduced by the *Niches Acoustiques* sound art installation is inspired by the site of the installation and by the artistic intention to reinforce its urban relatedness; they combine sonic fragments recorded in the forecourts' urban surroundings, which are edited into new imaginary sonic landscape scenes and supplemented by their own 'musical shadows'. The present study focuses on these two types of sound materials, the original *Referential* sonic landscape scenes and their more *Abstract* musical shadows, derived from the original scenes through two different editing procedures corresponding to two degrees of (preprocessed) abstraction: medium-abstraction and total-abstraction.

The Referential scenes were based on field recordings (not to be confused with the baseline, they are unrelated to the measurement campaign described Section 3.2.1.1) in various streets and public spaces surrounding the Forecourt, using stereo and directional mono microphones. These recordings were first cut into semantic and sonic units, differentiating between more continuous textures and more punctual events. Given the intended brevity of the composition excerpts, only a few of these units were used, selected for their semantic and sonic variety. The resulting Referential scenes were composed following a semantic and associative approach, and grouped into two different sound types: narrative scenes, combining various sound events with widely varying dynamics (instruments-paths, birds-games and voices), and natural tones, which present simpler, more continuous sound textures (articulate waters, and wind-rustling foliage).

The medium-abstraction applies resonance effects on the referential compositions using pitch-based harmonic resonators tuned to pure octave chords or triad chords with some deviating notes, band-pass filters inverse to the Baseline's average spectral energy profile, and spectral freezing. The total-abstraction results from a melodic audio-to-midi-based synthesis using alternatively Ableton Live 11 Suite's (What's New in Live 11, 2024) built-in Audio-to-MIDI conversion function and Max's IM-I analyzer plugin (mapped to a E minor triad), directing the performance of a virtual instrument (a virtual bell piano included in Ableton Live 11's core library).

In addition to this evaluation of three distinct positions within the artistically imagined referential-to-abstract continuum, the study also explored another composition technique, combining the basic referential compositions with their different abstractions in hybrid, steady mixes—simple combination of excerpts using signal addition—or fluctuating mixes—mixes that are constantly fluctuating between the referential scene and its abstract counterpart using an envelope automation in the form of a triangle wave with a period of roughly 40 seconds (0.025 Hz). These mixes correspond to the ultimate artistic intention to alternate between these different types of sounds in the final installation, based on environmental data captured on-site by acoustic and meteorological sensors.

Altogether, 26 installation excerpts (composed added sounds) resulting from the above-described composition strategies, each 95 seconds long, were presented to the participants. Five concrete, Referential excerpts were chosen based on samples from the original field recordings, and were either event-based (narrative scenes) or texture-based (natural tones).

To reach a reasonable experiment duration, we had to make a selection from all the possible compositional variations derived from these five Referential compositions. Four selected excerpts made with four different resonant and spectral manipulations applied on the Referential excerpts presented a medium-abstraction compositional position (Resonated excerpts, see Figure 3.4). The four manipulations alternate between and combine in different ways band-pass filters, pitch-based harmonic resonators and spectral freezing.

In comparison, total-abstraction was presented by two Synthesized excerpts, created with two different synthesizers (virtual instruments) based on a pitch-based audio-to-midi conversion of the concrete excerpts (see Figure 3.4).

The remaining mixed excerpts are combinations of Referential and mid-abstraction (Resonated) excerpts and of Referential and total-abstraction (Synthesized) excerpts, always maintaining the interplay of original referential sound and the abstraction derived from it. These compositions explore the two above-described mixing techniques, fluctuating mixes and steady mixes (see Figure 3.4).

The final selection of 26 excerpts comprises five Referential excerpts, four Resonated excerpts, two Synthesized excerpts, five mixes fluctuating between Referential and Resonated excerpts (Ref/Res Fluctuating), five mixes fluctuating between Referential and Synthesized excerpts (Ref/Syn Fluctuating), and five steady mixes superimposing Referential and Synthesized excerpts (Ref/Syn Steady). To characterize the acoustic levels of the excerpts, a series of 1min30s-sound level measurements was conducted in the listening room using a B&K 2238, in presence of the added sounds alone. Mean LAeq1min30s and LAFmax are reported in Table 3.1 and show that levels have similar ranges across composition strategies, except for Referential excerpts which have lower sound levels.

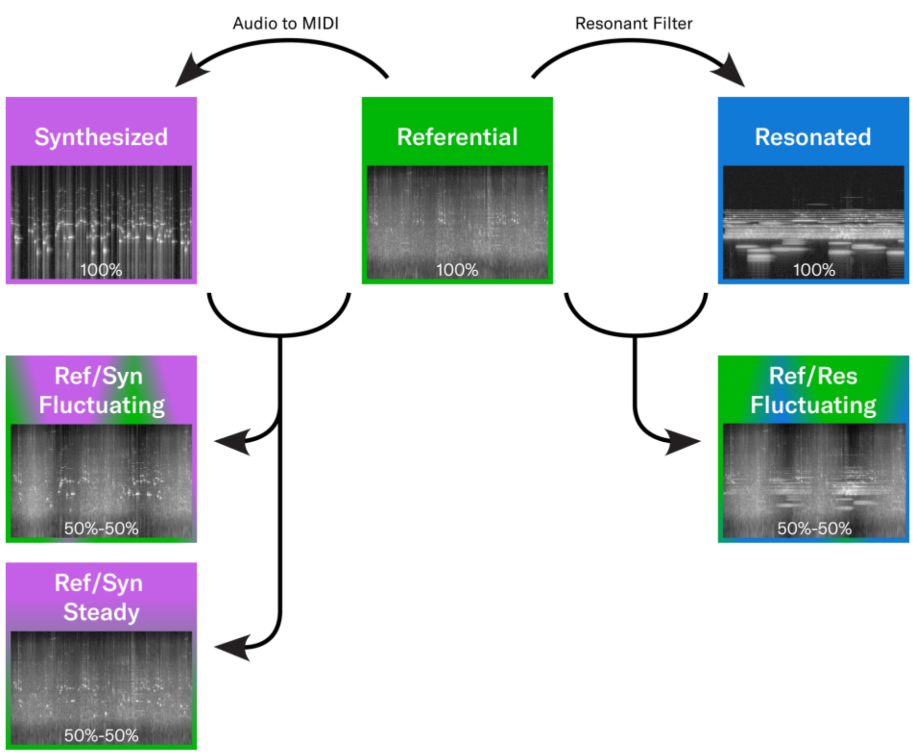


Figure 3.4. Diagram of the composition process operated on Referential excerpts, illustrated with six of the sound installation sketches' spectrograms obtained from the monophonic excerpts (before auralization) using python. Magenta corresponds to Synthesized excerpts, green to Referential excerpts, and blue to Resonated excerpts.

	Referential	Resonated	Synthesized	Ref/Res Fluctuating	Ref/Syn Fluctuating	Ref/Syn Steady
$L_{Aeq1m30s}$	54.1 (3.4)	61.8 (2.1)	59.7 (0.6)	58.8 (3.7)	58.8 (2.5)	59.4 (2.1)
L_{AFmax}	66.2 (8.2)	74.9 (5.5)	74.1 (2.9)	74.1 (6.1)	76.0 (4.2)	72.5 (5.0)

Table 3.1. Sound levels in the listening room, in presence of the added sounds only, collapsed over composition strategies: mean and standard deviation. The measurement period is 1m30s.

3.2.3. Soundscape evaluation

3.2.3.1. Participants

Twenty participants were recruited for the evaluation, including 9 Judicial Court workers (age = 44.1 ± 10.2) and 11 residents (age = 44.8 ± 13.5). All of them were familiar with the studied space to ensure ecological validity and self-reported normal hearing. Residents were recruited by distributing flyers and displaying posters in the neighborhood, while workers were recruited through an email sent from the borough to the Judicial Court's mail list. All participants reported using the public space several times a month, while a majority used it almost daily (see Table 3.2). They received a 20€ compensation for their participation.

	Several times a month	Several times a week	Almost daily
Residents	4	3	4
Workers	0	2	7
Total	4	5	11

Table 3.2. Participants' profile and attendance of the forecourt. No participants reported using the space less than once a month.

3.2.3.2. Conditions

Participants were continuously exposed to the baseline sound environment described Section 3.2.1.2 and evaluated it in the presence of added sounds pertaining to the different composition paradigms described Section 3.2.2. There was a total of 28 unique conditions, including the 26 compositions described in Section 3.2.2 as well as 2 conditions with no added sounds, including only the background sound environment at different, random moments in the experiment (Baseline). In total, the experiment featured 6 composition strategies (Referential, Resonated, Synthesized, Ref/Res Fluctuating, Ref/Syn Fluctuating and Ref/Syn Steady) for a total of 34 excerpts, including 6 duplicates (1×Referential, 2×Ref/Syn Fluctuating, 2×Ref/Res Fluctuating, 1×Ref/Syn Steady) to measure test-retest reliability.

3.2.3.3. Procedure

Participants were seated at the sweet spot of the speaker dome with a rotating chair fixed to the floor (*Figure 3.5* – left) and evaluated the excerpts through a Max interface displayed on a 21.5 inches monitor using an external mouse (*Figure 3.5* – right). In presence of the background sound environment, participants were first presented with a photograph and an aerial view of the studied site (*Figure 3.6*) for 40 seconds, while being asked to try to recall the space in their memory. They were then asked to listen to the 34 excerpts and evaluate their soundscape through a set of continuous scales (*Figure 3.5* – right and Table 3.3). All excerpts and all scales were presented in a fully randomized order. Within each trial, each excerpt was presented to the participants for 15 seconds before the questionnaire appeared to ensure they listened and acclimated to the soundscape. They could then answer the questionnaire for 75 s before the end of the excerpts that lasted a total of 95 s. However, they were able to skip to the next excerpt with a dedicated button (*Figure 3.5* – right, top right corner) that appeared after 50 seconds (including the initial 15 seconds), provided that they had filled all scales. A 10-second transition was set to smoothly switch between excerpts either when participants used the skip button or at the end of the excerpt. Depending on the participant, trials lasted between 60 s and 100 s for a total testing time between roughly 40 minutes and 1 hour.

The participant ran a practice trial with the experimenter before starting the experiment, to help them familiarize themselves with the task. An optional break was automatically triggered at the halfway point of the experiment (after the 17^{th} excerpt).

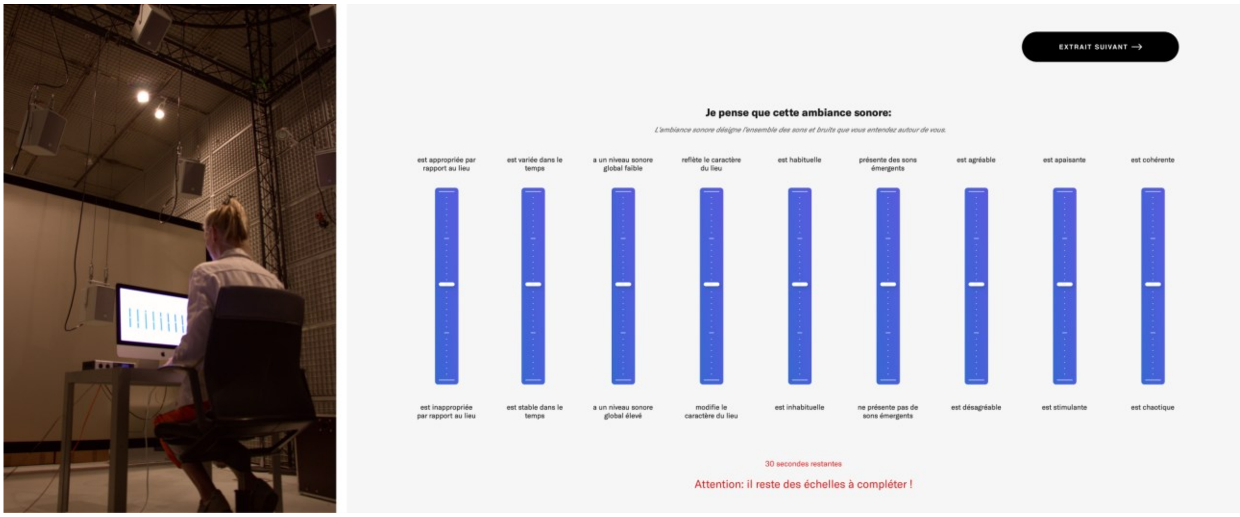


Figure 3.5. Left: photograph of the listening room illustrating the evaluation procedure (picture: Valérian Fraisse); right: Max interface provided to the participants.

Figure 3.6. Left: aerial view (picture: Google [2021]); right: photograph of the space (picture: Valérian Fraisse). Both photographs were presented simultaneously, at the beginning of the listening tests.

At the end of the experiment, the experimenter conducted a semi-structured interview (DeJonckheere & Vaughn, 2019) with the participants through an interview guide of six questions (Table 3.4). Participants were recorded with a Zoom H4N pro (*H4n Pro Four-Track Audio Recorder*, 2023). Interviews lasted from roughly 10 to 30 minutes. The entire study lasted around 90 minutes in total.

3.2.3.4. Questionnaire

Participants were asked to evaluate soundscapes across nine continuous semantic differential scales (Table 3.3). The elaboration of the questionnaire is the result of shared reflection between the sound artist (the second author) and the scientific team (all the other authors) to provide an evaluation tool both suitable for comparing soundscape interventions and relevant with regard to the design goals of the installation, while ensuring questionnaire brevity. In short, we needed to investigate not only how the added sounds could affect the perceived affective quality of the Forecourt's soundscape (ISO TS 12913-3, 2019, p. 3), but also their emotional impact (Welch et al., 2019), as well as how they could evoke novelty (i.e. less familiar soundscapes) and variation in an urban soundscape dominated by traffic, as it is one of the goals of the future sound installation. The questionnaire does not comprise scales related to the soundscape's *eventfulness*, as it is believed to be more related to human sounds, especially its French translation (Axelsson et al., 2010; Tarlao, Aumond, et al., 2023). Rather, we used questions relative to *variation* and *emergence,* in an attempt to capture the attributes of *eventfulness* that are not related to notions of human activities or liveliness, but instead to more analytical dimensions related to the perceived number of sources and their dynamics (Tarlao, Aumond, et al., 2023). The order of the scales was fully randomized between participants.

Variable	Positive end (translation EN)	Negative end (translation EN)	Positive end (original FR)	Negative end (original FR)
		To me, this soundscape :		*Je pense que cette ambiance sonore :*
Pleasant	*is pleasant*	*is unpleasant*	*est agréable*	*est désagréable*
Soothing	*is soothing*	*is arousing*	*est apaisante*	*est stimulante*
Sound Level	*has globally a low sound level*	*has globally a high sound level*	*a un niveau sonore global faible*	*a un niveau sonore global élevé*
Character	*reflects the character of the space*	*changes the character of the space*	*reflète le charactère du lieu*	*modifie le charactère du lieu*
Appropriate	*is appropriate to the space*	*is inappropriate to the space*	*est appropriée par rapport au lieu*	*est inappropriée par rapport au lieu*
Familiar	*is familiar*	*is unfamiliar*	*est habituelle*	*est inhabituelle*
Coherent	*is coherent*	*is chaotic*	*est cohérente*	*est chaotique*
Varied	*is varied over time*	*is stable over time*	*est variée dans le temps*	*est stable dans le temps*
Emergence	*has emerging sounds*	*does not have emerging sounds*	*présente des sons émergents*	*ne présente pas de sons émergents*

Table 3.3. Questions for each of the 34 laboratory conditions. Original French and English translation. Scales are continuous from 1 (Negative end) to 100 (Positive end). Participants were provided with a definition of soundscape which can be translated into: "The soundscape is the collection of all the sounds and noises that you hear around you."

3.2.3.5. Follow-up interviews

The experiment was followed by semi-structured interviews based on six questions (Table 3.4). The goal of the interviews was to obtain interpretative guidance on the results obtained with the scales, but also to identify participants' opinions on the added sounds and their relationship with the forecourt of the Judicial Court. Quotes reported in the results were translated from French by the first author.

Question (translation EN)	Question (original FR)
Generally speaking, how do you feel about these listening sessions?	*De manière générale, quel est votre ressenti par rapport à ces écoutes ?*
Were there any remarkable, out of the ordinary soundscapes during your listening? If so, which ones? Would they be desirable in the forecourt of the Judicial Court?	*Y'a-t-il eu des environnements sonores remarquables durant vos écoutes, qui sortent de l'ordinaire ? Si oui, lesquels ? Seraient-t-ils désirables sur le parvis du Tribunal Judiciaire ?*
What would you like to hear in this space that was missing in this experiment?	*Qu'aimeriez-vous entendre dans cet espace, et qui manquait dans cette expérience ?*
What brings you to the forecourt of the Judicial Court?	*Qu'est-ce qui vous amène sur le parvis du Tribunal Judiciaire ?*
What do you think about the forecourt of the Judicial Court?	*Que pensez-vous du parvis du Tribunal Judiciaire ?*
Do you have any comments, anything to add?	*Avez-vous des remarques, quelque chose à ajouter ?*

Table 3.4. Interview guide for the follow-up semi-structured interviews.

3.2.4. Data analysis

Statistical analyses were computed in R 4.0.3 with RStudio 2022.12.0+353 for Windows, with a statistical significance level of 0.05. Prior to the analysis, ratings were collapsed for each participant across duplicate conditions with the mean value, including the two conditions with no added sounds. The data was highly non-normal, whether univariate or multivariate. For this reason and because of the relatively small sample size, we decided to conduct semi-parametric and non-parametric analyses when relevant. To investigate the two research questions, we conducted two types of statistical analysis.

To validate the questionnaire instrument and to determine components underlying soundscape judgements in presence of sound art while increasing interpretability of the results [RQ1], we ran a Principal Components Analysis (PCA) on the 9 items with oblique rotation (*oblimin*) using the psych package version 2.0.9 (Revelle, 2022). Prior to the PCA, the Kaiser-Meyer-Olkin verified the sampling adequacy KMO = .76 ('middling', according to Kaiser, 1974), and all KMO values for individual items were above .6, which is above the acceptable limit of .5. Subsequent analyses were made from the resulting components of the PCA, shown in italics.

To investigate the effect of the added sounds on soundscape evaluation and to compare composition strategies [RQ2], we conducted two semi-parametric repeated measures MANOVAs with the components from the PCA as dependent variables and the composition strategy as independent variables using the multRM function from the MANOVA.RM package, version 0.5.3 (Friedrich et al., 2018). The first MANOVA was conducted with the composition strategy excluding mixes (Baseline; Referential; Resonated; Synthesized) as a within-subject factor to compare the influence of added sounds along the referential/abstract paradigm. The second MANOVA was conducted on all composition strategies (Referential; Synthesized; Ref/Res Fluctuating; Ref/Syn Fluctuating; Ref/Syn Steady) in the within-subject factor to evaluate the influence of the combination of abstract and referential sounds on soundscape evaluation. Since the covariance matrix was singular in some cases and because of the small sample size, we used the Modified ANOVA-type statistic (MATS) and wild bootstrap resampling method for p-values, with 10,000 iterations (Friedrich et al., 2017). For both tests, follow-up semi-parametric repeated measures ANOVA were conducted with the same independent variables using the ANOVA-type statistics (ATS) and wild bootstrap resampling also with 10,000 iterations from the RM function in the MANOVA.RM package. Finally, we ran *post-hoc* Wilcoxon signed rank exact tests to compare each condition, with Holm p-value correction using the R package stats (*Stats Package - RDocumentation*, 2023). For each Wilcoxon test, we report on p-values in addition to the *r* effect size estimated using the package rstatix (Rosenthal, 1991; *Wilcoxon Effect Size — Wilcox_effsize*, n.d.). For the MANOVAs and subsequent analyses, data was collapsed for each participant with the mean value corresponding to each condition.

For interpretative guidance on the quantitative results, follow-up interviews where transcribed and analyzed using NVivo 1.7.1 for Windows (*NVivo*, 2024), using Open coding to identify emerging themes (Allsop et al., 2022).

3.3. Results

3.3.1. Baseline evaluation and methodological validation

The 20 participants rated the Baseline soundscape as mildly pleasant (Mdn = 57.0) and neither soothing nor arousing (Mdn = 50.2). The reproduction of the forecourt's soundscape was perceived as representative of the forecourt of the Judicial Court as participants rated the Baseline soundscape as appropriate with the forecourt (Mdn = 71.5), familiar (Mdn = 84.7) and reflecting the character of the space (Mdn = 77.2). Six participants stated in the follow-up interviews that the experiment was realistic and representative of the forecourt (e.g. *"I closed my eyes and I really had the sensation that I was on the forecourt"*), while only one participant questioned its realism (*"I don't know whether car noises where artificial or not"*). The systematic exclusion of salient or disruptive sounds from the Baseline's concatenated excerpts is reflected in participants' ratings, as they rated it as being stable over time (Mdn = 35.7) and with an average emergence (Mdn = 49.5). Conversely and despite the Baseline's perceived Sound Level being mildly low (Mdn = 61.2), six participants described the listening experiment as globally loud, while one participant stated that it was quieter than in situ. Table 3.5 shows the full list of values for the Baseline condition.

Pleasant	Soothing	Sound Level	Character	Appropriate
57.0(14)	50.2(19)	61.2(22)	77.2(31)	71.5(14)
Familiar	Coherent	Varied	Emergence	
84.7(25)	78.7(29)	35.7(28)	49.5(30)	

Table 3.5. Scales for the baseline condition: median and inter-quartile range

To assess the test-retest reliability of the participants' ratings, the values obtained for the 6 excerpts that appeared twice were correlated using Pearson's coefficient of correlation. The test-retest reliability was found to be poor. The mean correlation across the 9 items was 0.5 with a range of 0.41-0.60. Results were similar when comparing the two baseline conditions with a mean correlation of 0.56 across all scales, with the exception of the scales Varied ($r = 0.21$) and Coherent ($r = 0.84$). However, Cronbach's α values for internal consistency suggested that the scales were reliable to some extent (Table 3.6).

3.3.2. Principal components analysis

An initial analysis was done to obtain eigenvalues for each component in the data. Based on the scree plot and in accordance with Kaiser's criterion (eigenvalues > 1.0), three components were retained that explained 74% of the variance.

The items that cluster on the same components suggest that component 1 (*Pleasant*) represents the soundscape's appreciation (29%), component 2 (*Familiar*) is associated with the character, familiarity and appropriateness of the soundscape (28%), while component 3 (*Varied*) is linked to the variety and emergence of the soundscape (16%). See Table 3.6 for component loadings. Both the soundscape's appreciation and character had high reliabilities (Cronbach's α = .84 and .83, respectively). However, the soundscape's variety had relatively low reliability (Cronbach's α = .60). These values suggest that the participants' ratings were reliable despite the poor test-retest scores. All items mostly load on only one component with a complexity ranging from 1.0 to 1.3, except for Coherent, which loaded both on soundscape's appreciation and character with a complexity of 2.

Item	*Pleasant*	*Familiar*	*Varied*
Pleasant	**.90**	.09	.03
Soothing	**.90**	-.08	-.02
Sound Level	**.76**	-.06	-.16
Character	-.02	**.89**	-.03
Appropriate	.22	**.84**	.11
Familiar	-.28	**.83**	-.12
Coherent	**.50**	**.56**	-.05
Varied	-.03	.04	**.84**
Emergence	-.04	-.05	**.83**
Eigenvalue	2.63	2.56	1.48
Variance explained (%)	29	28	16
Cronbach's α	.84	.83	.60

Table 3.6. Oblimin rotated component loadings of the PCA (N=540; RMSR = .07; fit = .96). Loadings above .3 appear in bold in greyed cells.

The three components emerging from the data show similarities with some of the components first identified by Axelsson et al. (Axelsson et al., 2010) and later confirmed by Tarlao et al. (Tarlao et al., 2021). See the discussion for further comparisons. These components will be used in the next sections to compare the composition sketches.

3.3.3. Abstract and referential composition strategies

In this section, we compare the three composition strategies (Referential, Resonated and Synthesized excerpts) with the Baseline condition. The overall repeated-measure MANOVA on these four conditions shows a significant effect of composition strategy on the three components ($MATS \approx 98.16$, $p < 0.001$). Follow-up repeated measures ANOVAs show a significant effect of composition strategy on all components (*Pleasant*: $ATS \approx 4.5$, $p \approx 0.009$; *Familiar*: $ATS \approx 29.5$, $p<0.001$; *Varied*: $ATS \approx 16.7$, $p<0.001$).

Descriptive statistics are shown in Figure 3.7 and in Table 3.9, while results of the *post hoc* tests are shown in Table 3.7. Together, they reveal that:

- For the *Pleasant* component, the Synthesized excerpts were significantly less appreciated than the Referential condition. However, there were no significant differences between the other conditions, despite moderate effect sizes suggesting that the Synthesized excerpts may be less appreciated than the Referential excerpts ($r=.49$) and the Resonated excerpts ($r=.40$).
- For the *Familiar* component, all conditions were significantly different from one another except for the Resonated and Synthesized excerpts. Specifically, all excerpts were perceived as being strongly less *familiar* than the Baseline. In addition, both Resonated and Synthesized excerpts were perceived as being less *familiar* than Referential excerpts.
- For the *Varied* component, the Baseline condition was perceived as being less *varied* than any other condition. Despite being significant, effect sizes suggest that Resonated ($r=.49$) and Synthesized excerpts ($r=.43$) were perceived as being more *varied* than Referential excerpts.

	Pleasant		*Familiar*		*Varied*	
	r	p	r	p	r	p
Baseline – Referential	.14	.996	.86	**<.001**	.88	**<.001**
Baseline – Resonated	.16	.996	.88	**<.001**	.85	**<.001**
Baseline – Synthesized	.49	.133	.87	**<.001**	.81	**<.001**
Referential – Resonated	.23	.935	.60	**.011**	.49	.080
Referential – Synthesized	.61	**.029**	.63	**.011**	.43	.106
Resonated – Synthesized	.40	.303	.18	.430	.22	.330

Table 3.7. Statistical significance in the change of the soundscape components with the composition strategy excluding mixes: Holm post-hoc Wilcoxon signed-rank exact tests and r effect size estimate.

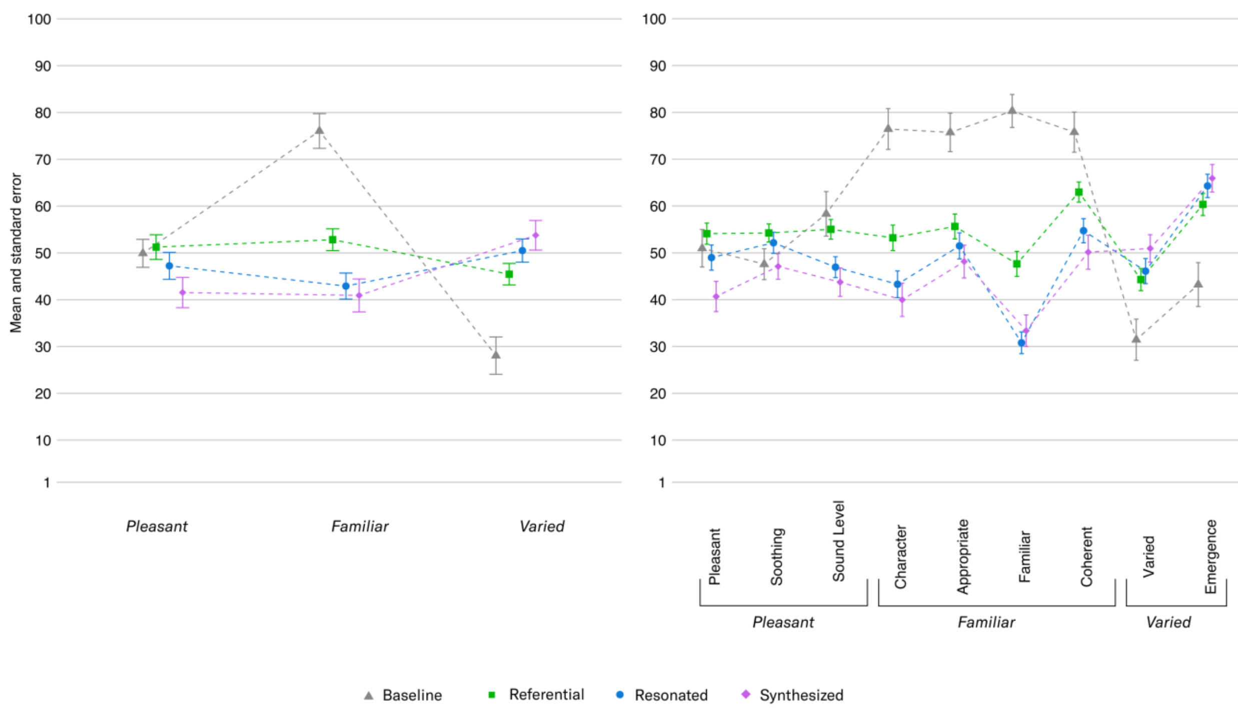


Figure 3.7. Mean ratings and standard error for the PCA components (left) and for all scales (right), collapsed over all participants, by condition excluding mixes (N=260). Post-hoc tests reveal that Synthesized excerpts were significantly less pleasant than Referential excerpts and all three composition strategies were significantly less familiar and more varied than the Baseline. In addition, Resonated and Synthesized excerpts were significantly less familiar than Referential excerpts.

If we did not observe the impact of composition strategies on soundscape appreciation except for Synthesized excerpts which were less appreciated that Referential excerpts, results suggest that all composition strategies substantially affected soundscape *familiarity* and *variety*. Specifically, the Resonated and Synthesized excerpts more strongly affected the *familiarity* compared to the Referential excerpts, while effect sizes suggest that they also more strongly affected the perceived *variety*.

3.3.4. Hybrid composition strategies

In this section, we only report on results relative to hybrid composition strategies (i.e. mixes between referential and abstract compositions) as the Referential, Resonated and Synthesized excerpts have been discussed before. The overall repeated-measure MANOVA on the conditions excluding the Baseline (Concrete; Referential; Synthesized; Ref/Res Fluctuating; Ref/Syn Fluctuating; Ref/Syn Steady) shows a significant effect of composition strategy on the three components (MATS ≈ 41.65, $p < 0.001$). Follow-up repeated measures ANOVAs show a significant effect of excerpt on all components (*Pleasant*: ATS ≈ 3.8, $p = 0.007$; *Familiar*: ATS ≈ 5.4, $p = 0.005$; *Varied*: ATS ≈ 6.6, $p = 0.002$).

Descriptive statistics are shown in *Figure 3.8* and Table 3.9, while results of the post hoc tests are shown in Table 3.8. Together, they reveal that:

- For the *Pleasant* component, there were no significant differences between conditions, despite moderate effect sizes suggesting that Ref/Syn Fluctuating and Ref/Syn Steady excerpts were less *pleasant* than Referential excerpts (r=.61 and r=.49, resp.) and that Ref/Res Fluctuating and Ref/Syn Steady excerpts were more *pleasant* than Synthesized excerpts (r=.45 and r=.47, resp.).
- For the *Familiar* component, Ref/Syn Fluctuating and Ref/Syn Steady excerpts were significantly less *familiar* than Referential excerpts. Despite being significant, moderate effect sizes suggest that the other mix strategy (Ref/Res Fluctuating) was also being perceived as less *familiar* than Referential excerpts (r=.48). Effect sizes also suggest that the Ref/Res Fluctuating excerpts were perceived as more *familiar* than

Resonated excerpts (r=.44), that the Ref/Syn Steady and Ref/Res Fluctuating excerpts were more *familiar* than the Synthesized excerpts (r = .47 and r = .43, resp.), and finally that Ref/Res Fluctuating excerpts were more *familiar* than the Ref/Syn Fluctuating excerpts (r=.48).

- For the *Varied* component, all three mix strategies (Ref/Res Fluctuating, Ref/Syn Fluctuating and Ref/Syn Steady) were significantly more *varied* than Referential excerpts. Despite being significant, moderate effect sizes suggest that all three mix strategies were also perceived as being more *varied* than Resonated excerpts (r=.54, r=.55 and r=.42, resp.).

	Pleasant		*Familiar*		*Varied*	
	r	p	r	p	r	p
Referential – Resonated	.23	1.00	.60	.067	.49	.266
Referential – Synthesized	.61	.073	.63	**.047**	.43	.479
Referential – Ref/Res F.	.34	1.00	.48	.360	.83	**<.001**
Referential – Ref/Syn F.	.61	.073	.72	**.009**	.74	**.005**
Referential – Ref/Syn S.	.49	.346	.68	**.020**	.63	**.048**
Resonated – Synthesized	.40	.759	.18	1.00	.22	1.00
Resonated – Ref/Res F.	.07	1.00	.44	.387	.54	.150
Resonated – Ref/Syn F.	.28	1.00	.18	1.00	.55	.145
Resonated – Ref/Syn S.	.05	1.00	.28	1.00	.42	.510
Synthesized – Ref/Res F.	.45	.485	.43	.408	.23	1.00
Synthesized – Ref/Syn F.	.31	1.00	.33	.857	.31	1.00
Synthesized – Ref/Syn S.	.47	.435	.47	.360	.11	1.00
Ref/Res F. – Ref/Syn F.	.39	.759	.48	.360	.09	1.00
Ref/Res F. – Ref/Syn S.	.14	1.00	.27	1.00	.32	1.00
Ref/Syn F. – Ref/Syn S.	.23	1.00	.19	1.00	.29	1.00

Table 3.8. Statistical significance in change of the soundscape components with the composition strategy excluding the baseline: Holm post-hoc Wilcoxon signed rank exact tests and effect size estimate.

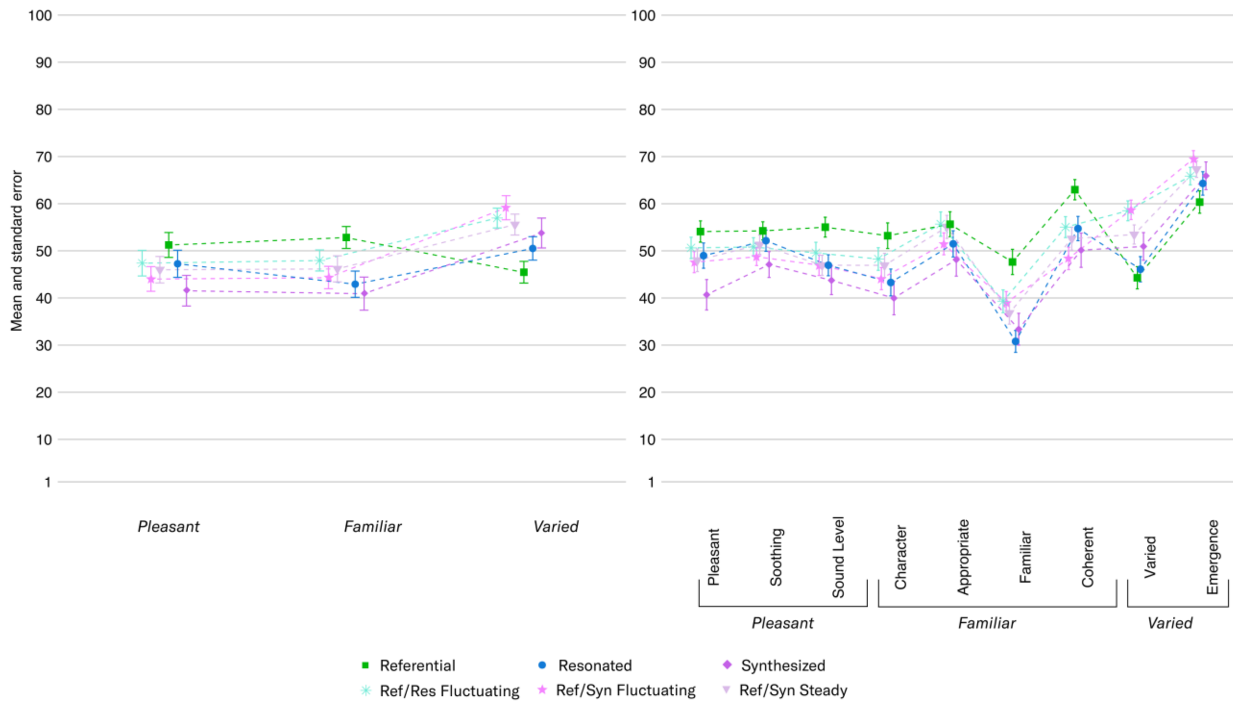


Figure 3.8. Mean ratings and standard error for the PCA components (left) and for all scales (right), collapsed over all participants, by condition excluding the baseline (N=440). Post-hoc tests reveal that Referential excerpts were significantly more familiar than Ref/Syn Steady and Ref/Syn Fluctuating excerpts and less varied than all three mix strategies (Ref/Res Fluctuating, Ref/Syn Fluctuating and Ref/Syn Steady).

	Pleasant		*Familiar*		*Varied*	
	Median	IQR	Median	IQR	Median	IQR
Baseline	54.4	8.31	76.1	32.2	31.8	26.5
Referential	51.4	13.5	52.8	10.5	45.1	11.3
Resonated	50.0	13.8	41.7	10.3	49.3	16.4
Synthesized	43.7	16.9	42.4	17.8	56.0	16.0
Ref/Res Fluctuating	48.0	7.98	50.1	8.52	56.9	10.4
Ref/Syn Fluctuating	46.4	12.5	45.2	10.8	56.8	16.0
Ref/Syn Steady	45.4	12.6	46.5	13.6	53.7	11.7

Table 3.9. PCA Components for all conditions (previously collapsed across composition strategies, N=140).

Results indicate that soundscapes with mixed excerpts might be more *pleasant* than those with Synthesized excerpts and less *pleasant* than those with Referential excerpts, although we could not identify significant differences. Mixed excerpts were also less *familiar* and more *varied* than those with Referential excerpts, while effect sizes suggest that they tended to be more *familiar* than those with Synthesized and Resonated excerpts, as well as more *varied* than those with Resonated excerpts. Otherwise, we did not detect significant differences between the ratings of the three hybrid composition strategies across all components, although effect sizes suggest that Ref/Res Fluctuating excerpts might have been perceived as more *familiar* than Ref/Syn Fluctuating excerpts. Overall, results suggest that soundscapes with hybrid compositions fall in between purely referential and purely abstract compositions in terms of *pleasantness* and *variety*, while they were perceived as being more *varied* than Referential excerpts, and potentially than Resonated excerpts.

3.3.5. Synthesis and qualitative exploration

During the interviews, all twenty participants referred to at least one referential sound such as birdsong (N=17), wind/rain (N=9), kids playing (N=14) or water (N=13) while sixteen participants mentioned abstract sounds through diverse associations (e.g. *"some kind of music"*, "*electroacoustic music"*, *"electronic sounds"*, "*metallic noise"*, "*crystal sounds"*). These mentions provide interpretative guidance on the quantitative results. Since it is unclear as to which specific condition the participants actually referred to, the qualitative exploration that follows is only associated with Referential and Abstract composition strategies when relevant. It should be noted that Referential sounds are more often mentioned than Abstract sounds, likely because it is easier to describe identifiable sounds (in terms of sound source or action producing sound) than unidentifiable sounds as the latter cannot be ascribed to a specific cause (Lemaitre et al., 2010).

3.3.5.1. Opinion and appreciation of composition sketches

Interviews reveal that all participants had a positive opinion of at least one of the referential sounds, most often referring to nature sounds such as birdsong (N=13, e.g. "*I liked the sound of the birds. It struck me, yeah, it struck me.*"), or wind/rain (N=12, e.g. "*the rustling leaves, I enjoyed them*"), while nine participants also had a negative opinion of at least one of the referential sounds, most often water (N=6, e.g. "*the sounds from the water, they were a little unpleasant*"). Opinion on Abstract sounds was given by only thirteen participants and was positive for four participants (e.g. *"there were tones that pleased the ear"*), mixed for five participants (e.g. *"for the electronic sounds[...], they were aggressive. [...] Some other were more balanced, I could consider them."*), and negative for four participants (*"the metallic noise would be unpleasant"*). Overall, Referential composition strategies were more often described positively than negatively during the interviews, and participants particularly enjoyed natural sounds such as birdsongs and wind or rain. However, the difference in *Pleasant* ratings between Referential excerpts and the Baseline did not reach statistical significance. Conversely, Abstract strategies were described equally often positively and negatively, but among them, Synthesized excerpts were rated significantly lower than the Baseline and than most of the other conditions on the *Pleasant* component. These results illustrate that interviews can provide more nuanced evaluations than scales alone. They also suggest that people agree more easily on what they do not like than on what they like when describing sound art interventions.

3.3.5.2. Familiarity and appropriateness

To the question: *"Were there any remarkable, out of the ordinary soundscapes during your listening?"*, all participants mentioned at least one of the Referential sounds and half of them mentioned at least one of the Abstract sounds. Fourteen participants stated that at least one of the added sounds was unfamiliar or surprising. Among them, five participants reflected on the potential of added sounds to transport them elsewhere (e.g. *"there was one that was completely different, that took us completely elsewhere"*) or to remind them of nearby parks (e.g. *"the fact that we could hear [birds], it reminded me of* *the park next door"*), highlighting the restorative potential of added sounds. Conversely, nine participants were concerned about the added sounds' appropriateness. Among those that explained why, some felt that the purpose of site was incompatible with sound art (e.g. "*I had some trouble imagining how you could hear music next to a judicial court. I don't know, maybe it's a misconception because it would be very pleasant."*; *"I don't find [the added sounds] appropriate for the place, which is majestic, it's the judicial court. [...] It represents Justice."*), while others thought it might be disruptive (e.g. "*they may not be adapted for someone who wants to read or sit next to it*").

The data from the interviews was consistent with participants' ratings, where both Referential and Abstract composition strategies had a strong impact on soundscape *familiarity* when compared to the Baseline. The interviews also confirm the close relationship between *familiarity* and *appropriateness* found in the PCA and illustrate the challenge of proposing a sound installation that gives people the impression of being away while still being appropriate for the site. As a participant pointed out: "*On the one hand, it is totally inappropriate because unfortunately it is uncommon to hear sound art in public spaces [...]. On the other hand, it would be appropriate because it would allow us to disconnect from the soundscapes we are used to hearing"*.

3.3.5.3. Emergence, variety and masking

The propensity of added sounds to emerge from the soundscape or to bring variety was not directly discussed in the interviews, except for a few rare mentions (e.g. a participant when talking about the added sounds: *"it's pretty varied"*). However, eight participants stated that the added sounds had a masking effect on the existing sound environment, referring to either Referential sounds (e.g. *"there was some kind of a rain sound that soothed everything and was very enveloping"*), Abstract sounds (e.g. *"sometimes the electroacoustic music masks the traffic noise"*), mixed excerpts (e.g. *"The water sounds with the birds and the gong-like sound [...]; the mix between them covers the annoying background noise, we almost don't hear it anymore"*) or as a whole (e.g. *"I was hearing the sounds and I thought: well, that's good, it compensates well, it envelops well the sounds from the cars"*).

These direct references provide evidence that sound art has the potential to provide a form of non-energetic masking from unwanted noise in the existing environment, as is often discussed by sound artists (e.g., Anderson, 2008; Rudi, 2005; Tittel, 2009; Vogel, 2013) and was recently observed in a few studies (Cerwén, 2016; Oberman et al., 2020; Van Renterghem et al., 2020). Though non-energetic masking was not directly measured, it is likely related to the rise in soundscape *variety* and *emergence* caused by both Referential and Abstract composition strategies during the listening test.

3.3.5.4. Hybrid composition strategies

Participants did not refer to the mixes between Abstract and Referential excerpts, except for the one above-quoted mention. Rather, their description of the soundscapes was either general or focused on a specific sound. It suggests that the combination of composition strategies did not raise specific concerns or strong opinions, explaining why the evaluation of hybrid composition strategies fell in between that of Abstract and Referential compositions regarding *pleasantness* and *familiarity*.

3.4. Discussion

3.4.1. Components underlying soundscape evaluation in presence of sound art

In answer to the first research question [RQ1], our results suggest that the evaluation of everyday city soundscape modified by the presence of sound art can be described in terms of three components: *Pleasant*, *Familiar* and *Varied*. The first component, *Pleasant*, was found to explain 29% of the variance in soundscape measures and is analogous to the *pleasantness* component used in the model presented in the ISO 12913-2:2018, proposed by Axelsson et al. and validated by Tarlao et al. (Axelsson et al., 2010; ISO TS 12913-3, 2019; Tarlao et al., 2021). This component allowed to measure the impact of sound art interventions on soundscape appreciation. If *appropriateness* was loaded on a factor associated with *pleasantness* in Tarlao and colleagues' model (Tarlao et al., 2021), we found it associated with a different component, *Familiar*, that explains 28% of the variance. Similar to the *familiarity* identified by Axelsson et al. (Axelsson et al., 2010) while explaining a greater amount of variance, it played a significant role in the comparison of composition strategies. Our study suggests that assessing soundscape's *familiarity* is necessary when evaluating and comparing sound art interventions as it allows to gauge how their inclusion can evoke novelty in a familiar soundscape, specifically how they can lead to less *familiar* soundscapes by disrupting the rhythms that dominate the urban experience, without a positive or negative connotation(Lacey, 2016b). This also corroborates Oberman and colleagues' observation that sound art interventions could influence the *appropriateness* of the sound environment (Oberman et al., 2020). The third component, *Varied*, was found to explain 16% of the variance, and seems to be inversely related with *monotonous* observed by Tarlao et al. (Tarlao et al., 2019). *Varied* was related with the variety and number of sources but was believed to be less related to the presence of sources denoting human activities than *eventfulness* (Tarlao, Aumond, et al., 2023). This component provided information on the propensity of sound art interventions to rise above the existing soundscape and can be meaningful to position sound art within an *integrated/oppositional* dichotomy (Livingston, 2016). Further research is required to assess the comparative performance of scales relative to *variety* and *eventfulness* to describe variation in soundscape, and their relationship with sounds from human activity.

Together, these results suggest that a model for soundscape evaluation solely based on *pleasantness* and *eventfulness* as proposed in the ISOs 12913-2:2018 and 12913-3:2019 may be incomplete to assess sound art installations and/or unconventional soundscape interventions and situations. Although it provides adequate characterizations of soundscapes (Tarlao et al., 2021), this two-dimensional model does not allow to evaluate how soundscape interventions can (positively) reshape or reconfigure urban soundscapes, i.e. their impact on *familiarity* or on *variety*, even though these aspects are often critical to sound artists (e.g., see Lacey, 2016).

3.4.2. Impact of composition strategies on soundscape measurement

To answer the second research question [RQ2], we compared the impact of different sound art composition strategies on quantitative and qualitative soundscape measurement. The sound design methodology proposed by the second author allowed to gather sketches of the sound installation in the form of excerpts into six composition strategies that we positioned within an Abstract (sounds that can't be ascribed to any real or imagined provenance) / Referential (recorded sounds that suggest or at least do not hide the source to which they belong) dichotomy (Landy, 2007). If all added sounds led to less *familiar* and more *varied* soundscapes, results show that Abstract sounds more affected soundscape *familiarity* and were perceived as more *varied* than Referential sounds. These effects were similar for Synthesized excerpts (note-to-midi abstractions of the Referential excerpts, see section 3.2.2) than Resonated effects (filtering of the Referential excerpts), while the evaluation of hybrid composition strategies (mixes between Referential and Synthesized or Resonated excerpts) fell in between that of purely Abstract and purely Referential composition strategies regarding *familiarity*, but were overall perceived as being more *varied*. This suggests that the impact of the added sounds on *familiarity* was more pronounced with deeper sonic abstractions and was somehow proportional to the ratio of Abstract/Referential sounds within the compositions, while hybrid composition strategies were overall perceived as more *varied,* likely due to a greater diversity of sound sources. Together with the qualitative feedback, this confirms our prior intuition that more processed, artificial sounds can be considered more *oppositional* as they were perceived as more *varied* and less *familiar* than recorded sounds, hinting to a non-energetic masking that is stronger when sounds are least expected. Still, hybrid compositions received the highest scores on the *varied* components, highlighting the role of soundscapes' diversity on perceived *variety*. Some of the participants also reflected on the ability of the added sounds to transport them elsewhere, evidencing the potential for sound art interventions to improve the restorativeness of a space by allowing its users to experience a sense of being-away (Payne, 2013). Otherwise, we couldn't observe the impact of the composition strategies on soundscape appreciation except for Synthesized excerpts that were rated significantly lower than Referential excerpts on the *Pleasant* component. Incidentally, we acknowledge that person-related factors—specifically whether participants were local residents or workers, but also variables such as age or sensitivity (Tarlao et al., 2021)—may influence people's evaluation of the forecourt's soundscape in presence of added sounds. Further analysis is required to investigate the relationship between these person-related factors and the impact of sound installations.

Follow-up interviews provided more nuanced feedback and showed that participants' opinion on Referential excerpts was generally positive especially when they referred to natural sounds (in line with recent works; see for instance Hong et al., 2020; Jeon et al., 2010; Lugten et al., 2018; Ong et al., 2019) while it was more nuanced regarding Abstract sounds. This suggests that participants more easily reached a consensus when evaluating least liked excerpts than preferred ones. Incidentally, we could not observe significant results in situations where the effect size was small to moderate. This indicates a probable lack of statistical power due to the small sample size, constrained because of the inclusion criterion requiring that participants are familiar with the forecourt of the Judicial Court. This could explain why we did not detect significant differences between conditions on the *Pleasant* component when qualitative results suggested otherwise. This advocates for further research on the impact of sound art interventions on soundscape appreciation.

3.4.3. Methodological outcomes

The proposed methodology was the result of shared reflections between the scientific team and the sound artist (the second author) to help inform the composition of a public space sound installation prior to its deployment while investigating our research questions [RQ1] and [RQ2]. This research-creation methodology was fruitful both for the sound artist by providing perceptual feedback on sketches of the sound installation and for the scientific team in generating theoretical knowledge on the relationship between sound art composition strategies and their impact on soundscape evaluation.

In this study, we validated the soundscape simulation tool (Fraisse, Schütz, et al., 2022) in a context of comparison between sound art interventions: participants recognized the Baseline sound environment as familiar and realistic and we observed significant differences between composition strategies across all components. However, the sound environment was only representative of the forecourt's average level of activity, and the removal of disruptive sounds and especially of sirens during the edition of HOA recordings tempered its validity, as those sounds are part of the identity of the Judicial Court: for instance, five participants mentioned that sirens were missing from the soundscape during the follow-up interviews (e.g. "*I expected to hear a lot more sirens*"). Further work is required to evaluate the impact of the *Niche Acoustiques* sound installation over different scenarios representative of the diversity of sound environments that can be heard within the forecourt. Conversely, the sound installation sketches were made up of elementary building blocks to allow the comparison of well-delineated composition strategies. Another study is required to evaluate compositions that will be closer to the final installation and consider different soundscape scenarios related to different times and days of the week. Otherwise, we could not evaluate the influence of prolonged or repeated exposure of public space users to the sound installation, a key feature as it will be permanently integrated into the public space. This was also a constraint for the second author in their creation process as the final composition is intended to evolve over long periods of time. It should also be noted that although our participants were seated in a fixed location, users will experience the installation on-site while moving through space, which will modulate their exposure to added sounds and create variations across space. Other sensory modalities, including visual cues (Li & Lau, 2020) may also influence the reception of the sound installation.

Regarding the questionnaire itself, the three components not only helped understand how public space users evaluate familiar soundscapes in the presence of sound art [RQ1] but facilitated the comparison of the sonic contents [RQ2] and provided useful, easy to understand feedback to the second author in their creative process: reduced into these three components, the results helped assess how the different composition strategies affected soundscapes in relation to the installation's design goals. In addition, follow-up interviews provided interpretative guidance by revealing the multifaceted nature of the components and evidencing the presence of non-energetic masking, advocating the use of methodological triangulation (Botteldooren et al., 2023; ISO TS 12913-3, 2019). To the sound artist, these interviews were considered insightful as they provided an in-depth understanding of participants' perceptual and emotional feedback and a contextualization of the quantitative results. Moreover, outputs from the interviews allowed the sound artist to better identify compositional outcomes pointed out with the quantitative results. Open-ended responses from participants in relation to *familiarity* and *appropriateness* also highlighted the importance of previous experience of a specific site and of their relationship to the site. It is therefore important to collect participants' experience in their own words and beyond closed-ended questions, which is an oft-ignored recommendation from the ISO 12913 series.

3.4.4. Practical contributions

This experiment was part of a greater art-science collaboration to inform the composition of the *Niches Acoustiques* sound installation with soundscape evaluations. Future work includes the laboratory evaluation of more elaborate composition sketches in different usage scenarios of the forecourt, and a comparison between laboratory results and the in-situ evaluation of the sound installation once it is deployed.

Overall, this study showed the potential and feasibility for soundscape simulation to inform the composition of public space sound art prior to its deployment *in situ*. If it is possible to adjust the content of a sound installation once it is deployed or during its prototyping, the changes must be done under strong constraints (see for instance Anderson, 2008). In contrast, a laboratory setting provides the sound artist the opportunity to freely explore and anticipate the impact of composition strategies relevant to their artistic intention so that they can implement modifications before deployment, although the laboratory situation considerably restrains the compositional aspects to be evaluated (absence of characteristic multimodal and kinesthetic aspects that come with *in situ* outdoors experience, time constraints, etc.). To find an answer to our research questions, we reported here on relations between broad composition strategies and their impact on soundscape measurement.

In the context of the composition of the sound installation *Niches Acoustiques*, the experiment yielded valuable perceptual feedback on the effect of elementary compositional materials on soundscape evaluation, a first step towards their combination into finite compositions and their mapping with data collected by the future installation using environmental sensors. On this matter, an excerpt-to-excerpt analysis was also useful as it provided detailed feedback on the sound installation sketches. Ultimately, the experiment showed that the sound installation could provide novelty and variety in the forecourt's soundscape and advocated the use of hybrid compositions to achieve such a goal without reducing soundscape appreciation. Furthermore, participants' feedback implicitly indicated a potential that the present composition samples haven't explored yet with regard to such a hybrid composition strategy; the combination of the two different referential sound types (narrative scenes and natural tones) as a composition/sound production basis, with their different temporal and spectral implications.

In terms of design and planning, this experiment highlights the potential of sound installation to affect soundscape *familiarity* and *variety* and the relationship between the Abstract/Referential nature of added sounds and their impact on these components. While we believe that some of these outcomes might transfer to other sound installations, sound art in public spaces is closely related to site-specific characteristics, which should be accounted for. We advocate for the use of similar methodologies for the design and evaluation of sound installations throughout the creation process, to better understand the complex and crucial role of sound in everyday experiences of public spaces.

3.5. Transition

This chapter focused on a laboratory evaluation as part of a still ongoing research-creation collaboration with sound artist Nadine Schütz around the design of the permanent sound installation Niches Acoustiques. This collaboration was especially extensive because of the length and nature of the artistic project, but also because my presence at IRCAM coincided with the sound installation's planning phase, so that we were able to carry out in-depth methodological and theoretical research ahead of the deployment of the future installation. The project began in 2021 with a series of sound recording and acoustic measurements (reported in Fraisse, Nicolas, et al., 2022), included the development of a soundscape simulation tool (see Fraisse, Schütz, et al., 2022), and led to the laboratory evaluation of Niche Acoustiques' composition sketches. The laboratory results presented in this chapter offer new insights into the primary research questions of this thesis: they helped understand the relationship between the nature of added sounds and their impact on soundscape, while validating the use of the soundscape simulation tool for prototyping sound installations with perceptual evaluations.

At this point, it was important to further investigate the methodological and theoretical findings from the two previous studies. First, additional work was needed to develop a comprehensive research-creation framework for guiding the design of public space installations, which will be presented in chapter 5. In that matter, we wanted to determine how the collaborative process undergone with *Niches Acoustiques*—from initial field recordings and measurements to laboratory evaluations—could be applied in a shorter time interval and with a different artistic project. Second, it was important to address some limitations of the current study, particularly regarding the follow-up interviews. Despite the valuable insights these interviews provided to the composer, we could not pinpoint which specific conditions participants were referencing. To offer better guidance for the design of sound installations, a protocol improvement was necessary to gather qualitative feedback on each condition evaluated in laboratory settings. Finally, studying a different sound installation would yield theoretical insights complementary to the findings from the previous two studies.

In pursuit of these goals, chapter 4 presents the outcomes of a second laboratory study undertaken in collaboration with sound artist Charles Montambault, focusing on the development of his permanent sound installation *Les Madelinéennes*, in Montreal.

CHAPTER 4. BRINGING THE COASTLINE TO THE CITY: LABORATORY EVALUATION OF A PUBLIC SPACE SOUND INSTALLATION[7]

Abstract

This paper discusses a research-creation collaboration around the design and evaluation of the permanent public space sound installation *Les Madelinéennes* by Charles Montambault, installed in a small urban public space. We report on a study to inform the composition of the 2024 iteration of the sound installation. Nearby residents familiar with the space (N=25) were invited to evaluate soundscapes in laboratory settings, combining Ambisonics recordings of the site with spatialized composition sketches, simulating different sound installations in the public space. The compositions featured natural sounds and soundmarks evocative of a coastal area (various combinations of sea waves, wind, sea birds and mammals, and boat sounds). Participants were invited to evaluate the different soundscapes along semantic scales, identify significant moments in each soundscape, and then describe them in follow-up interviews. The results reveal effects of unusual sounds in everyday soundscapes, highlighting the challenges of transposing natural sounds and soundmarks of a coastal area to an urban location: the

[7] This chapter is a version of Fraisse, V., Montambault, C., Wanderley, M. M., & Guastavino, C. (Manuscript to be submitted). Bringing the coastline to the city: Laboratory evaluation of a public space sound installation.

most evocative sounds (boat horns, seagulls, cormorants) were perceived as less appropriate and less pleasant, while the least evocative sounds (wind, sparrow) were evaluated as the most pleasant and soothing. Furthermore, the interviews revealed a wide diversity of associations to the added sounds related to previous experience. Overall, the experiment was well received by the local community, who indicated their willingness to spend more time in the park in the presence of the installation. Several design recommendations were derived from the study to inform the composition of the next iteration of the installation.

4.1. Introduction

Art can shape the human experience of urban public space in various ways, for instance by improving their aesthetics, by increasing social cohesion, or by stimulating critical reflection (Hoop et al., 2022). Within this broad umbrella, public space sound installation art emerged as an artistic practice in the second half of the 20th century (Ouzounian, 2021). Sound installations, which involve the articulation of curated sounds in space (Bandt, 2006), have the potential to reconfigure the auditory experience of a site and expand its affective potential (Lacey, 2016b).

In parallel, the soundscape approach has developed into a research field in its own in recent decades (Guastavino, 2020). With a central focus on human perception and context (ISO TS 12913-1, 2014), soundscape research considers sound as a resource that can be designed and planned (Brown & Muhar, 2004; Cerwén et al., 2017; C. C. Moshona et al., 2024). In this regard, sound artists can provide site-specific designs solutions that are highly relevant to the soundscape approach (Cobussen, 2023). Nonetheless, only a handful of studies have been investigating how curated sound installations can shape the auditory experience of public space users. A few field studies shown that installations can lead to improvements in the overall auditory evaluation of urban public spaces (Jambrošić et al., 2013; Fraisse, Tarlao, et al., 2024), transform and make more positive the perception of traffic noise (Pink et al., 2019), motivate specific behaviors (Arroyo et al., 2012; Adhitya, 2017), or foster social interaction (Franinovic & Visell, 2007; Gronbæk et al., 2012; Steele, Bild, et al., 2019). In a laboratory study by Hellström and colleagues

(2014), participants reported a mild preference for sound art installation when compared to a control condition, although the added sounds were often confused with the pre-existing sound environment. Conversely, Oberman et al. showed improvements in soundscape ratings in the presence of three sound installations in different public spaces, through laboratory simulation of soundwalks (Oberman et al., 2020). Given the scarcity of studies on the subject and the absence of methods to inform the design of sound installations with soundscape evaluation, we recently proposed a sound installation simulation tool (Fraisse, Schütz, et al., 2022), which was used to investigate the impact of a public space sound installation in Paris (Fraisse, Schütz, et al., 2024). The study showed that the added sounds altered the pre-existing soundscape's *familiarity* and *variety* in relation to their abstract nature (whether they could be associated to an identifiable source, see Landy, 2007).

While there is little research on the soundscape impacts of sound installations, extensive research exists on the soundscape effects of generic music (e.g., Aletta et al., 2016; Meng et al., 2018; Steele et al., 2021) and of natural sounds such as water sounds or bird sounds. The positive effects of water sounds on soundscape quality and their propensity to reduce the perceived loudness of traffic noise have been broadly demonstrated (e.g., Nilsson et al., 2010; Jeon et al., 2012; Galbrun & Ali, 2013; Hong, Ong, et al., 2020; Hong, Lam, et al., 2020a; Lee & Lee, 2020), although several studies showed more nuanced results, especially in presence of traffic noise from small to medium roads (De Coensel et al., 2011; Axelsson et al., 2014; Trudeau et al., 2020). Several studies show that introducing bird sounds usually improve the soundscape quality of urban spaces (e.g., Chau et al., 2023; Chen & Kang, 2023; Hong, Ong, et al., 2020; Van Renterghem et al., 2020). But again, some studies had more nuanced results, showing for instance that these potential benefits varied by bird species (Jeon et al., 2010; J. Y. Hong, Lam, et al., 2020; Zhao et al., 2020) or were related to the congruence of the birds' presence (Franěk et al., 2019; J. Y. Hong, Lam, et al., 2020). Apart from a reduction of perceived loudness and improvements in overall soundscape evaluations, a key factor of investigation in most of these studies is the restorative potential of natural sounds: studies overall converge to identify restorative outcomes associated with listening to natural sounds (Ratcliffe, 2021).

The present study, building upon these different bodies on literature, involves the laboratory evaluation of a sound installation based on natural sounds and soundmarks (as defined in Schafer, 1977) evocative of the sea. It was conducted in the context of a research-creation collaboration between the authors of this paper relative to the design of the permanent sound art installation *Les Madelinéennes*. Created by sound artist and second author Charles Montambault, *Les Madelinéennes* is currently deployed in the Parc des Madelinots, a small urban public space in the Verdun borough of Montreal, Canada. Verdun was a major destination for emigrants from the Magdalen Islands (a Québécois archipelago in Quebec), resulting in a significant socio-cultural relationship between Verdun and the Magdalen Islands. *Les Madelinéennes* highlights the cultural heritage of the Magdalen community through compositions based on field recordings from the Magdalen Islands, in an attempt to link the two territories and to sensitize the Parc des Madelinots' users to their surroundings. Inspired by the concepts of acoustic ecology (Schafer, 1977), Bégout's ambiance (Bégout, 2020) and of the ecology of attention (Citton, 2017), but also by the aesthetic and functional codes of ambient music formulated by Brian Eno (Eno, 1978), the sound installation seeks to foster experiences of reconnection—whether conscious or unconscious—with Verdun's atmospheric and cultural identity by alluding to the Magdalen Islands. The objective of *Les Madelinéennes* is to offer a pleasant and soothing listening experience that evokes the Magdalen atmosphere.

We conducted a laboratory evaluation to inform the composition of the 2024 iteration of the sound installation. Twenty-five residents familiar with the space were invited to evaluate soundscapes in laboratory settings using ambient sound recordings of the small park with the addition of spatialized composition sketches, simulating different sound installations in the public space. The composition sketches featured sounds recorded in the Magdalen Islands in varying quantities (various combinations of sea waves, wind, sea birds and mammals, and boat sounds). During the experiment, participants were invited to evaluate the different soundscapes along semantic scales, identify soundmarks in each soundscape, and then freely describe them in a semi-structured interview while listening back to moments that were significant to them, in an approach inspired by the reactivated listening method proposed by the CRESSON research team (Augoyard, 2001).

While this experiment is intended to help inform the design of *Les Madelinéennes* sound installation, it also represents a unique opportunity to investigate the soundscape effects of natural sounds and soundmarks of a coastal location—here, the Magdalen Islands—transposed to a different context, in an urban location. In comparison to other studies investigating the soundscape effects of natural sounds, which usually involve factorial designs (e.g., Nilsson et al., 2010) or sound sequences (e.g., Han et al., 2023), the stimuli investigated here are prototypes of the sound installation pertaining to different composition strategies: they involve more complex combinations of natural and human sounds, have an intentional narrative, and can be seen as design prototypes rather than strictly controlled stimuli (Stappers & Giaccardi, 2014). Here we seek to investigate the soundscape effects of these sound sources' average presence in the compositions, in presence of a background sound environment representative of the studied site, but without manipulating each sound source individually. Rather, we seek to evaluate the perceived source dominance, how noticeable they are, how they might distract listeners' attention away from other sound sources through attentional of non-energetic masking (see Fraisse, Schütz, et al., 2024 for a review), as well as their restorative potential. As there are very few studies on the soundscape effects of sound installation art, we also expect to capture soundscape effects that may have not been previously observed. On methodological grounds, this study seeks to extend a soundscape simulation tool developed in a previous study (Fraisse, Schütz, et al., 2024) and further investigate the relevance and productivity of describing significant moments in interviews following soundscape evaluation to better understand the complexities of the listening experience.

4.2. Method

4.2.1. Soundscape simulation

The present study uses a soundscape simulation tool previously developed and experimentally validated (see Fraisse et al., 2022). The tool consists of the reproduction of Ambisonics field recordings of the public space's sound environment—the Baseline—, along with the auralization of the sound installation—the Added Sounds—using a 3D acoustic model of the site (simulating early reflections and late reverberation), converted to a Higher-Order Ambisonics (HOA) stream. The resulting soundscape is presented over a loudspeaker array for real-time evaluation using continuous scales. All components of the experiment, including the auralization, Ambisonics decoding and playback, and the graphical user interface are implemented in Cycling' 74 Max, v8.5.1 (*What Is Max?*, 2023).

4.2.1.1. Studied site and Baseline sound environment

The listening test focuses on the evaluation of a Baseline corresponding to Parc des Madelinots' pre-existing sound environment, in the presence and absence of several prototypes of the sound installation.

Parc des Madelinots is a small urban public space (around 600 square meters, see Figure 4.1) located in the Verdun borough of Montreal, Canada. Formerly a working-class neighborhood, the borough experienced a significant social transformation in recent decades, evolving into a coveted neighborhood with ample green spaces, amenities, and cultural events. However, the public space is exposed to high levels of traffic noise from two adjacent middle-sized streets (Lasalle Blvd and Wellington street), is sparsely used by residents, and is mostly perceived as a transit space.

The Baseline consists of a 3 min 10 s excerpt edited from in situ recordings and repeated over the different conditions (see Figure 4.2). Because the Baseline was to be representative of an average activity level, we performed 6 measurements sessions on weekdays, between 11 am and 4 pm. For each session, 30-minute to 1-hour recordings were performed in the middle of the public space using a Soundfield ST350 FOA microphone together with a B&K 2250 sound level meter to capture the equivalent sound pressure level and third-octave levels (see Figure 4.1). All measurements were oriented towards the north, at a height of 1.30 m, roughly corresponding to ear height in a seated position.

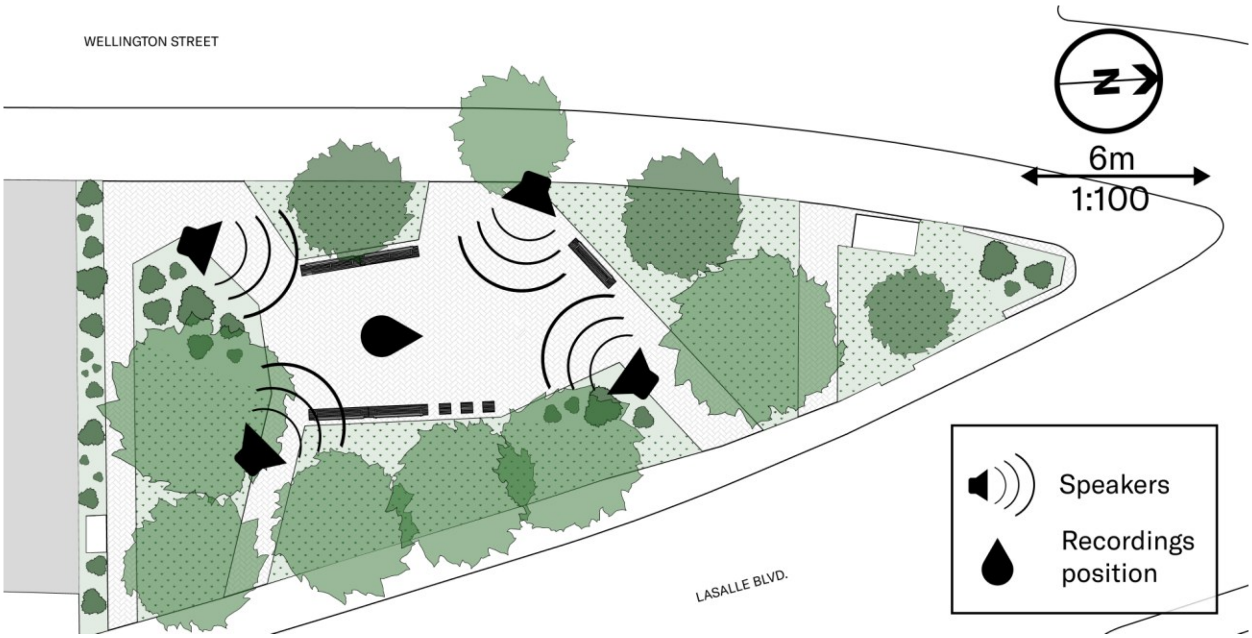


Figure 4.1. Map of the Parc des Madelinots public space, showing the position and orientation of the sound installation's speakers and recordings position, also corresponding to the simulated listening position.

The Baseline condition was edited from these recordings during joint listening sessions with two of the authors. First, excerpts were selected from the recordings to ensure that they were representative of the public space without containing too many salient sounds that could reinforce the identification of repetitions between the conditions. For example, we systematically excluded intelligible voices and sirens. Second, these excerpts were concatenated using a 3-second crossfade to provide short yet smooth and unnoticeable transitions. Three other recordings were similarly edited to provide a background sound environment during the training phase, the introduction phase, and the transition between trials (see Section 4.2.3.2).

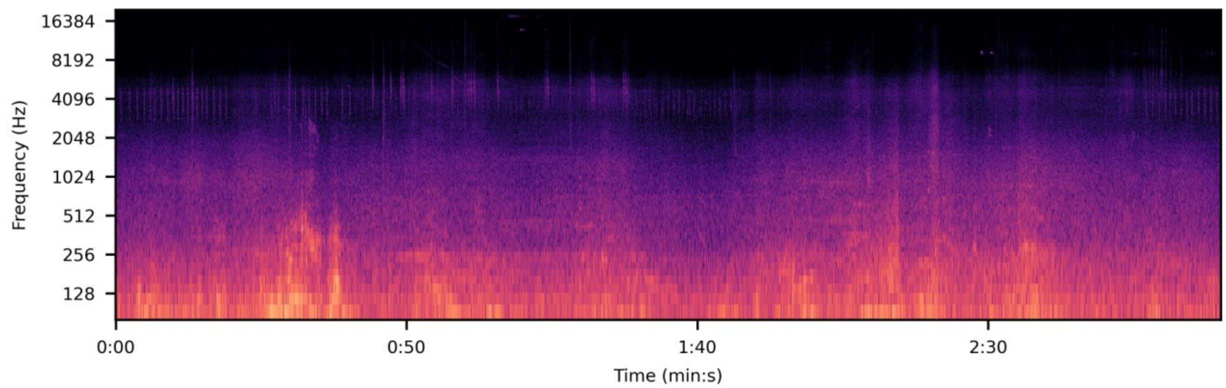


Figure 4.2. Spectrogram of the W (omnidirectional) canal of the Baseline condition, made with python's librosa library. FFT size: 2048; Hanning window; hop length: 512. The Baseline sound environment is dominated by traffic (high energy in the low and medium frequencies) which peaks at two periods (roughly at 30 s and 2 min 15 s).

The reproduction of the background sound environment was calibrated by comparing in situ $L_{Aeq,30min}$ values with similar measurements in the listening room's sweet spot. After calibration, a 2 minutes 55 seconds acoustic measurement of the Baseline (corresponding to the conditions' duration, excluding transitions) was conducted in the listening room using a B&K 2250. We measured a $L_{Aeq,2min55}$ of 57.5 dBA and a L_{A10}-L_{A90} of 7.8 dBA.

4.2.1.2. Added sounds auralization and mastering

The auralization method is briefly presented here, further detailed in (Fraisse, Schütz, et al., 2022). The Added Sounds from the sound installation are spatialized using IRCAM's EVERTims framework (Poirier-Quinot et al., 2017) from Max's spat~ library (*Spat | Ircam Forum*, 2023). Based on a 3D model including the public space's main surfaces, the position of the sound sources (the sound installation's speakers) and the listening position (see Figure 4.1), the auralization unit simulates the sources' early reflections and late reverberation. The output of the auralization unit is encoded into 4^{th} order HOA streams with spat~. Since the simulation tool had been fine-tuned for a different case study (see Fraisse et al., 2022), some parameters of the tool's late reverberation unit were adjusted by ear to fit with Parc des Madelinots. The mastering of the added sounds followed two steps: first, the loudness of the different excerpts was normalized with Reaper (*Reaper*, 2023) based on LUFS values. Then, the gain was adjusted by ear in presence of the Baseline sound environment by the composer (the second author) to mimic the protocol that is carried out to master the sound installation's in situ levels. Please note that the sound installation is in a dual stereo setup: in the listening room, one channel is auralized through the two top speakers, and another channel through the two bottom speakers in the map shown Figure 4.1.

4.2.1.3. Ambisonics reproduction

The experiment was conducted at CIRMMT's Performance Research Laboratory (PeRL), an acoustically treated listening room, over a hemispherical dome of 37 Genelec 8030 speakers (*CIRMMT Facilities*, 2024) placed on five height levels beginning at 30 cm. Both the auralized added sounds (HOA) and the baseline sound environment (FOA) were decoded with spat~ using energy preserving method with *max-re* weighting function (Zotter et al., 2012).

Figure 4.3. Photograph of the PeRL listening room. Credits: CIRMMT.

4.2.2. Conditions

Participants were asked to evaluate a total of twelve conditions presented in random order: the Baseline condition and eleven conditions where the composition described below are superimposed on the Baseline sound environment.

4.2.2.1. Added sounds composition

The rationale and intentions of *Les Madelinéennes* sound installation are described in the introduction. Below is a description of the different conditions and the associated composition strategies. All the conditions are based on field recordings from the Magdalen Islands with a Sennheiser MKH 418-S microphone (Sennheiser, 2024) equipped with a Røde Blimp-R windshield (Røde, 2024), and show different dominances of waves, wind, beaches, ports, seabirds, and sparrows sounds (see Table 4.1). All conditions present a diversity of sound sources that make up the soundscapes heard on the Magdalen Island. However, because the goal of the experiment was to investigate the role of specific sound sources and of their combinations on soundscape, some conditions mostly contain specific sound sources (e.g., Waves, Seagulls); while others contain a greater variety of sound sources (e.g. Water/Cormorant/Mast, Water/Sparrow; those are also excerpts of the currently deployed sound installation). Finally, two conditions are made of sounds not initially selected for the current installation to explore the soundscape effects of potentially less desirable sounds (Boat and Horn). Please note that 300 bird species can be found in the Magdalene Islands (*Bird Checklists of the World*, 2024) and not all of them were identified in the different excerpts, so only families of birds are mentioned throughout the manuscript: cormorants (*Phalacrocoracidae*), seagulls (*Laridae*, and especially *Larinae*), or sparrows (*Passeridae*). See Figure C.1, Figure C.2, and Figure C.3 for the spectrograms of the conditions. Finally, the main sound sources described in Table 4.1 only correspond to sources selected and perceived as dominant by the composer and the research team. The perceived sound source dominance reported in the rest of this article corresponds to the dominance reported by participants during the experiment.

Condition name	Description
Birds	A big flock of birds (including seagulls, cormorants) is dominant throughout the excerpt, with waves in the background.
Seagulls	Alternating cormorants and seagulls, with a flock of birds passing-by in the middle of the excerpts, with gentle waves in the background.
Sparrow	A sparrow is continuously singing in the foreground, with sea waves in the background
Cormorant/Mast	A flock of birds is present intermittently, with cormorants in the foreground and sea waves in the background. The sound of a cable hitting a boat mast is present throughout the condition.
Waves	Dominated by sea waves, with almost no other sound sources (small birds can be heard in the background).
Waves/Wind	Dominated by sea waves and wind, which are the only sound sources in this condition.
Waves/Horn	Sea waves can be heard in the background, with occasional seagulls, and a gentle boat horn in the beginning and in the end of the condition.
Waves/Sparrow	Sea waves that slowly evolve to wind can be heard in the foreground, with a sparrow in the background.
Waves/Seagulls	Sea waves (low frequency rumble) and seagulls can be heard in the foreground.
Boat	An idle boat's engine can be heard in the foreground, with some birds and waves in the background. An unintelligible public announcement can be heard twice (at 30s and 1min50s).
Horn	Dominated by waves with only a few birds in the background. A loud boat horn can be heard twice in the beginning.

Table 4.1. *Description of the main sound sources present in each condition. Other sounds can be sometimes present in the background as the conditions are based on field recordings in outdoor environments.*

4.2.2.2. Acoustic measurements

As for the Baseline condition (see 4.2.1.1), sound level measurements were performed in the sweet spot of the listening room, at a height of 1.30m and for a measurement time of 2 min 55 s. Measurements are reported in Table 4.2.

	Added Sounds only			Added Sounds with the Baseline			
Condition name	$L_{Aeq,2min55s}$	Loudness	L_{A10}	$L_{Aeq,2min55s}$	Loudness	L_{A10}	L_{A10}-L_{A90}
Baseline	N/A	N/A	N/A	57.6	12.1	60.4	7.9
Birds	62.9	13.2	65.9	64.0	17.8	66.9	7.3
Seagulls	59.2	10.7	62.1	61.5	15.8	64.4	8.3
Sparrow	55.4	10.6	58.1	59.6	15.2	62.1	5.9
Cormorant/Mast	56.2	9.2	58.5	59.9	14.7	62.3	6.0
Waves	59.8	11.5	61.6	61.8	15.5	63.8	4.6
Waves/Wind	55.7	9.1	57.3	59.7	13.8	61.8	5.0
Waves/Horn	57.9	10.1	59.8	60.7	15.2	63.0	5.0
Waves/Sparrow	56.5	9.8	58.5	60.1	14.6	62.1	4.8
Waves/Seagulls	55.9	9.8	57.4	59.8	14.4	62.3	6.0
Boat	62.5	15.1	65.4	63.7	17.4	66.5	7.1
Horn	60.8	14.0	62.0	62.5	16.8	64.1	4.6

Table 4.2. Acoustic measurements for each condition, for the added sounds only, and for the sound environments evaluated by the participants (added sounds with the baseline). Equivalent levels, percentiles and their differences in dB(A), and Zwicker's loudness in Sones.

4.2.3. Soundscape Evaluation

4.2.3.1. Participants and their relationship with the Parc des Madelinots

Twenty-five participants were recruited for the listening test (age = 43.6 ± 12.5; see noise sensitivity in Table 4.4) by distributing flyers and posting announcements on social media. Because Montreal is a bilingual city, the experiment was provided either in French or in English, depending on participants' preference (language: FR=16; EN=9) Criteria of inclusion include self-reported normal hearing and familiarity with the space to ensure that participants are representative of the studied population (public space users) for ecological validity. As shown in Table 4.3, participants use the Parc des Madelinots with different frequencies because they either live nearby, work nearby, or frequent the neighborhood on a regular basis (passers-by). When asked about their reasons for using the public spaces, participants mention that they most often pass-by (N=21, 8 of which exclusively), and occasionally take a break (N=9), stop there as it is the end of a pedestrianized area during summers (N=5), relax (N=4), attend cultural events (N=4), or wait (N=1). Finally, and among the 25 participants, one comes from the Madelinean diaspora.

	Less than once a month	Several times a month	Several times a week	Almost daily
Residents	3	6	2	3
Passers-by	2	5	3	0
Workers	1	0	0	0
Total	5	11	5	3

Table 4.3. Participants' profile and attendance of the Parc des Madelinots.

In general, I am sensitive to noise:				
Totally disagree	Disagree	Don't agree nor disagree	Agree	Totally agree
0	2	2	11	10

Table 4.4. Participants' sensitivity to noise

4.2.3.2. Procedure

Participants were seated at the sweet spot of the speaker dome (see Figure 4.3) and evaluated the excerpts through a Max interface displayed on a 24" monitor using an external mouse (see Figure 4.4).

Participants were first presented with two photographs of the public space for 80 seconds, while being asked to recall the space (see Figure 4.5). They were then asked to listen to the 12 conditions and evaluate both the perceived dominance of sound sources and the soundscapes through a set of continuous scales (see Figure 4.4, Table 4.5, and Table 4.6). In addition, and following previous observations that excerpt-to-excerpt qualitative feedback would be desirable in the follow-up interviews (Fraisse, Schütz, et al., 2024), participants could optionally click on a button at any time of a trial to indicate the presence of a significant moment that struck them for a reason or another (see Figure 4.4 – top right). All conditions and all scales (sound source scales and soundscape scales, respectively) were presented in a fully random order, with the exception of the "Other sounds" sound source scale which was always at the bottom. For each trial, conditions were presented for 15 seconds before the scales appeared to ensure they listened and acclimated to the soundscape, although the significant moment button is present from the beginning of the trial. Participants could then answer the questionnaire for 2 minutes 45 seconds. A 15-second transition was set to smoothly switch between trials.

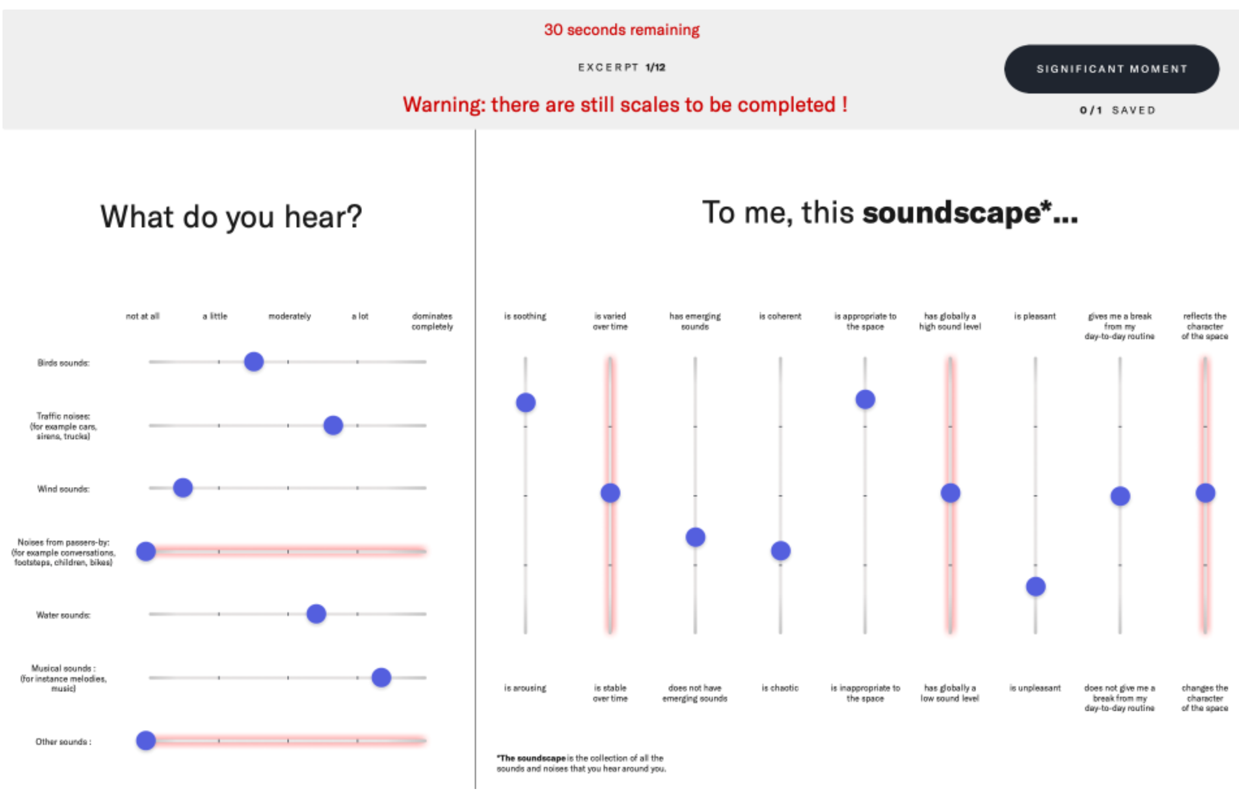


Figure 4.4. Screenshot of the Max interface during soundscape evaluation (a full description of the scales is available in Section 4.2.3.3). Participants are made aware of uncompleted scales 30s, 20s, and 10s before the end of a condition.

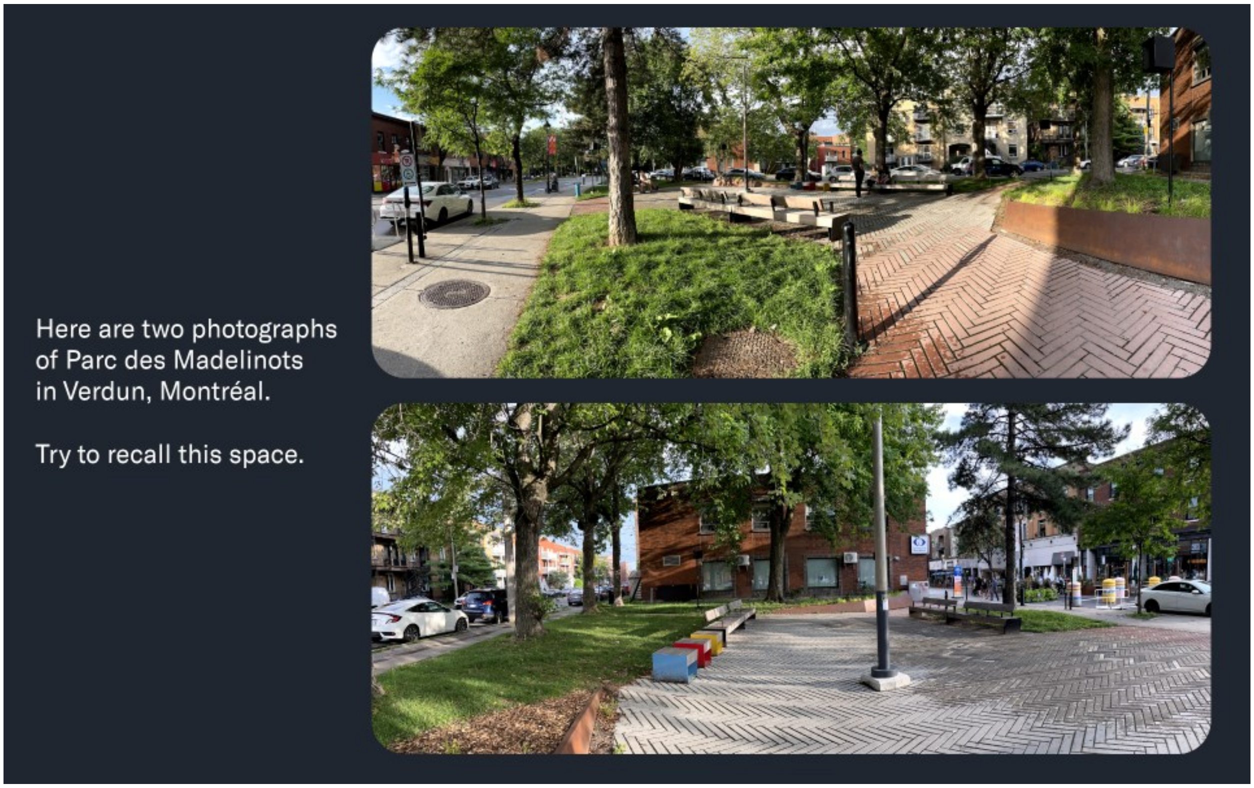


Figure 4.5. Screenshot of the Max interface showing two pictures of the Parc des Madelinots at the beginning of the experiment.

Participants were initially provided with an instruction sheet that detailed the nature of the experiment as well as the task, and notably disclosed that each condition was supposed to represent the same average period in the public space (see Figure C.4 and Figure C.5). After that and before starting the experiment, participants ran a practice trial in the experimenter's presence to familiarize themselves with the task. An optional break was automatically triggered at the halfway point of the experiment (after the 6th excerpt).

At the end of the experiment, the experimenter conducted a recorded semi-structured interview (DeJonckheere & Vaughn, 2019) with the participants through 13 questions (see the interview guide in Table C.1). Participants were able during the interviews to listen back to each of their significant moments and to discuss them with the experimenter: notably, they were invited to explain why a given moment was significant for them, what they feel about this moment, and whether the moment would correspond to a desirable experience in the public space. Other questions related to their general feedback on the experiment and the compositions, their relationship with the public space, and whether they belong to the Madelinean diaspora and if they were already aware of the presence of the installation in the public space.

4.2.3.3. Questionnaire

Participants were asked to evaluate their perceived dominance of sound sources as well as on their soundscapes across 16 continuous semantic differential scales, including 7 scales relative to the perceived dominance of sound sources (see Table 4.5), and 9 scales for soundscape evaluation (see Table 4.6).

The 7 scales relative to the perceived dominance of sound sources are derived from the sound source identification scales featured in the method C of the ISO/TS 12913-2 (2018), with a focus on nature sounds. The 9 scales for soundscape evaluation were informed from a previous study, and are related to three soundscape components that were shown to be relevant for evaluating the soundscape effects of public space sound installations: *pleasantness*, *variety*, and *familiarity* (see Fraisse et al., 2024). Scales relative to *pleasantness* (Pleasant and Soothing) are derived from the Perceived Affective Quality Scales (PAQS) presented in the ISO/TS 12913-2 (2018) and a set of semantic differentials proposed by Welch and colleagues (2019). They focus on the hedonic properties of the sound installation. Scales related to *familiarity* (Character, Appropriate, and Coherent) are partly derived from the PAQS and the Perceived Restorativeness Soundscape Scales (PRSS, see Payne, 2013), and focus on the capacity of the sound installation to reshape or reconfigure existing soundscapes (Lacey, 2016b; Fraisse, Schütz, et al., 2024). *Variety* (Varied, and Emergence) is comparable to *eventfulness* proposed in the PAQS but aims at measuring the influence of the sound installation on the perceived variety, number, and potential motion of sources rather than the presence of sources denoting human activities (Tarlao, Aumond, et al., 2023). In addition, Being-Away is derived from the PRSS and aims at measuring the installation's potential for disconnection through evocations, in relation to the installation's artistic intention.

Variable	EN	FR
	What do you hear?	*Qu'entendez-vous?*
Traffic	*Traffic noises (for example cars, sirens, trucks)*	*Bruits de traffic (par exemple voitures, sirènes, camions)*
Birds	*Birds sounds*	*Sons des oiseaux*
Wind	*Wind sounds*	*Son du vent*
Water	*Water sounds*	*Sons d'eau*
Music	*Musical sounds (for instance melodies, music)*	*Sons musicaux (par exemple mélodies, musique)*
Passers-by	*Noises from passers-by (for example conversations, footsteps, children, bikes)*	*Bruits des passants (par exemple conversations, bruits de pas, vélos)*
Other	*Other sounds*	*Autres sons*

Table 4.5. Scales relative to the perceived dominance of sound sources for each of the 12 laboratory conditions. French and English versions. Scales are continuous from 0 to 100 (0: not at all/pas du tout; 25: a little/un petit peu; 50: moderately/modérement; 75: a lot/beaucoup; 100: dominates completely/complètement dominant).

4.2.4. Data Analysis

Statistical analysis was performed using R v4.3.0 on RStudio v2023.06.0 with a statistical significance level of 0.05. Prior to the analysis, participants' mean value was imputed over 4 missing values (scales that were left untouched for a given condition). For many conditions and scales, the data was non-normal, and there were some outliers. For these reasons and because of the relatively small sample size, we decided to conduct non-parametric analyses when relevant. To investigate the research questions, we conducted two types of statistical analysis.

Variable	Positive end (EN)	Negative end (EN)	Positive end (FR)	Negative end (FR)
		To me, this soundscape:		*Je pense que cette ambiance sonore :*
Pleasant	*is pleasant*	*is unpleasant*	*est agréable*	*est désagréable*
Soothing	*is soothing*	*is arousing*	*est apaisante*	*est stimulante*
Sound Level	*has globally a high sound level*	*has globally a low sound level*	*a un niveau sonore global élevé*	*a un niveau sonore global faible*
Character	*reflects the character of the space*	*changes the character of the space*	*reflète le charactère du lieu*	*modifie le charactère du lieu*
Appropriate	*is appropriate to the space*	*is inappropriate to the space*	*est appropriée par rapport au lieu*	*est inappropriée par rapport au lieu*
Coherent	*is coherent*	*is chaotic*	*est cohérente*	*est chaotique*
Varied	*is varied over time*	*is stable over time*	*est variée dans le temps*	*est stable dans le temps*
Emergence	*has emerging sounds*	*does not have emerging sounds*	*présente des sons émergents*	*ne présente pas de sons émergents*
Being-Away	*gives me a break from my day-to-day routine*	*does not give me a break from my day-to-day routine*	*me déconnecte de ma routine quotidienne*	*ne me déconnecte pas de ma routine quotidienne*

Table 4.6. Soundscape scales for each of the 12 laboratory conditions. French and English versions. Scales are continuous from 0 (Negative end) to 100 (Positive end). Participants were provided with a definition of soundscape which can be translated into: "The soundscape is the collection of all the sounds and noises that you hear around you."

To categorize the conditions (i.e. the different excerpts), we applied an interval Multidimensional Scaling (MDS) algorithm on the answers from the 7 scales associated to the perceived dominance of sound sources, for all conditions excluding the Baseline. An 11×11 Euclidean distance matrix was first computed from a 11×175 matrix of individual answers (11 conditions × [25 participants × 7 scales]) using the package cluster (v2.1.3). Then, a two-dimensional representation of the distances between the conditions was computed using the Symmetric SMACOF algorithm from the package smacof (v2.1.6), minimizing Kruskal's normalized stress-1 to a value of 0.13 after 14 iterations. This solution was retained because of its relatively low stress value and its good interpretability (Mair et al., 2016).

To investigate the impact of the sound installation on the *Parc des Madelinots*' soundscape, we ran Wilcoxon signed rank exact tests using the package rstatix (v0.7.2) to compare each of the 11 excerpts with the Baseline on the 9 soundscape scales, with Benjamini-Hochberg p-value correction over the scales. For each Wilcoxon text, we report on p-values in addition to the r effect size and the associated 95% confidence interval based on percentile bootstrap with 1000 iterations, also computed with the package rstatix.

Follow-up interviews were transcribed and analyzed using NVivo v12.1.115 for Windows (*NVivo*, 2024) using open coding to identify emerging themes.

4.3. Results

4.3.1. Baseline evaluation

The 25 participants rated the Baseline soundscape as mildly pleasant (Median [Mdn] = 55), neither soothing nor arousing (Mdn = 53), while there seems to be no consensus on whether this soundscape allowed them to have a break from their day-to-day routine (Being-away: Mdn = 51; IQR = 43). The reproduction of the park's soundscape was rather representative of the *Parc des Madelinots*' soundscape, as it was perceived as appropriate to the space (Mdn = 74), although it less strongly reflected the character of the space (Mdn = 62). Follow-up interviews confirmed that the experiment was representative of the space, as mentioned by 10 participants (e.g., *"it's the sound environment I'm used to hearing"; "it accurately reflected the space"*), but at the same time 13 participants noticed a lack of sounds related to human presence compared to their experience of the space, which might explain the lower scores on Character (e.g., *"I was surprised I wasn't able to hear or there weren't more sounds reflecting people"*). Ultimately, the Baseline was not perceived as being too loud (Mdn = 41), although it was described as mildly Varied (Mdn = 62) and Emergent (Mdn = 63).

Being-away	Soothing	Pleasant	Sound Level	Character
51(43)	53(21)	55(33)	41(19)	62(18)
Appropriate	Coherent	Varied	Emergent	
74(22)	64(19)	62(29)	63(21)	

Table 4.7. Scales for the baseline condition: median and inter-quartile range

4.3.2. Categorization of conditions according to the perceived dominance of sound sources

The composition for each condition is described in Table 4.1, the perceived sound source dominance per condition is shown in Figure 4.6 while results of the MDS are shown in Figure 4.7. Figure 4.6 shows that Traffic noise was the most dominant sound source, followed by Bird sounds with a high variability across conditions. Wind, Water, Other and Passers-by were overall rated as less dominant more consistently across conditions. As shown in Figure 4.7, the MDS revealed three condition clusters described and compared to the Baseline condition as follows:

- *Birds dominant* conditions which contain prominent birds sounds (mostly seagulls, cormorants, and sparrows) and water/wind sounds in the background, associated to a stronger perceived dominance of birds. The condition Cormorant/Mast also includes sounds of steel cables clanging against a boat's mast, leading to an increased perceived dominance of other sounds.

- *Boat dominant* conditions, in which sounds related to maritime traffic are more prominent (boat horn, boat engine, public announcement), leading to an increased perceived dominance of traffic and other sounds, and a reduced perceived dominance of birds.

- *Water/wind dominant, hybrids*, which contain only water or wind sounds (Waves and Waves/Wind conditions) or include a balance of bird, water, wind and boat sounds (conditions Waves/Horn, Waves/Seagulls and Waves/Sparrow). These conditions were either associated with an increased perceived dominance of wind or water sounds (conditions Waves/Wind, Waves/Horn and Waves/Seagulls), and/or a decreased perceived dominance of Birds with no effects on the perceived dominance of other sounds (conditions Waves and Waves/Wind).

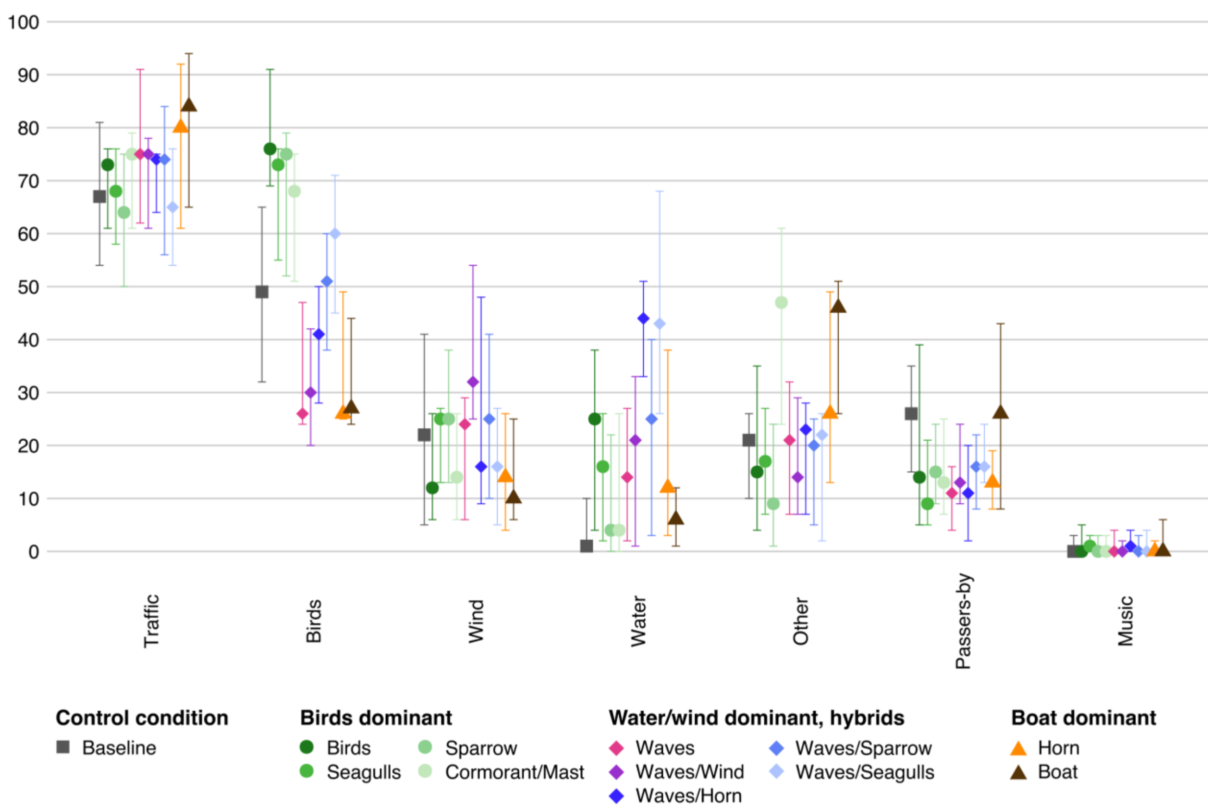
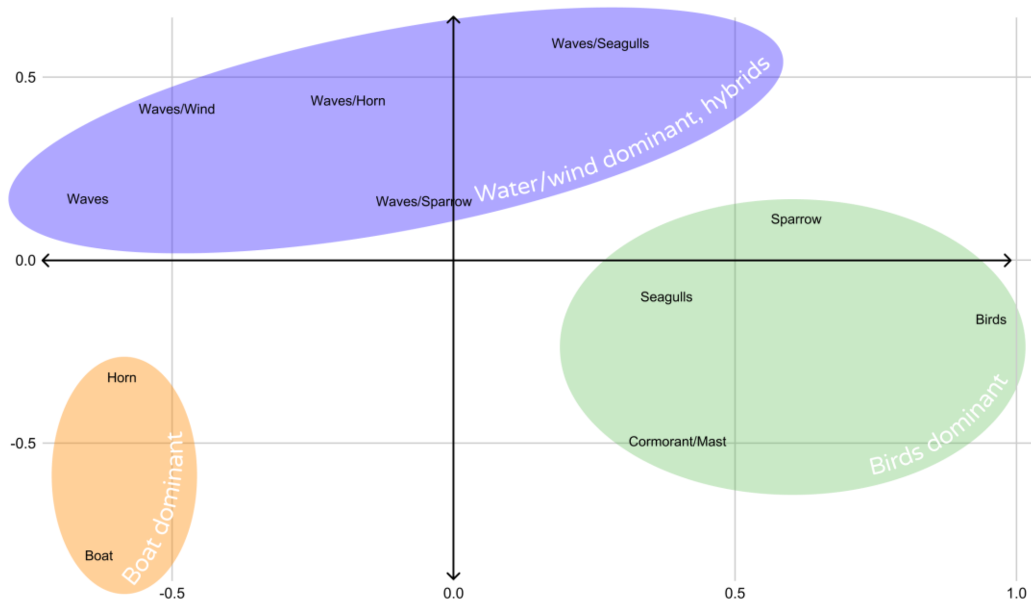


Figure 4.6. Perceived sound source dominance per condition: median, 25 and 75 percentiles.



1.

Figure 4.7. Multidimensional Scaling on conditions (excluding the Baseline) by sound source dominance (stress-1=0.13). Three clusters were identified and highlighted.

4.3.3. Impact of compositions on soundscape evaluation

A first exploration of soundscape ratings with the conditions collapsed over the three clusters (see Figure 4.8) shows that conditions with a dominance of nature sounds (*Birds dominant* and *Water/wind dominant, hybrids*) seem to have similar effects when compared to the Baseline: they do not strongly affect the existing soundscape on the Being-away, Pleasant, Soothing, and Emergent scales, but lead to an increase in the perceived Sound level, change the Character of the space, make it less Appropriate and Coherent (especially the *Bird dominant* conditions), but also less Varied (especially the *Water/Wind dominant, hybrids* conditions). On the other hand, *Boat dominant* conditions seem to more strongly affect the existing soundscape on the Sound level, Character, Appropriate, and Coherent scales, while they lead to a decrease in ratings for the scales Being-Away, Soothing and Pleasant, and an increase in perceived Emergence.

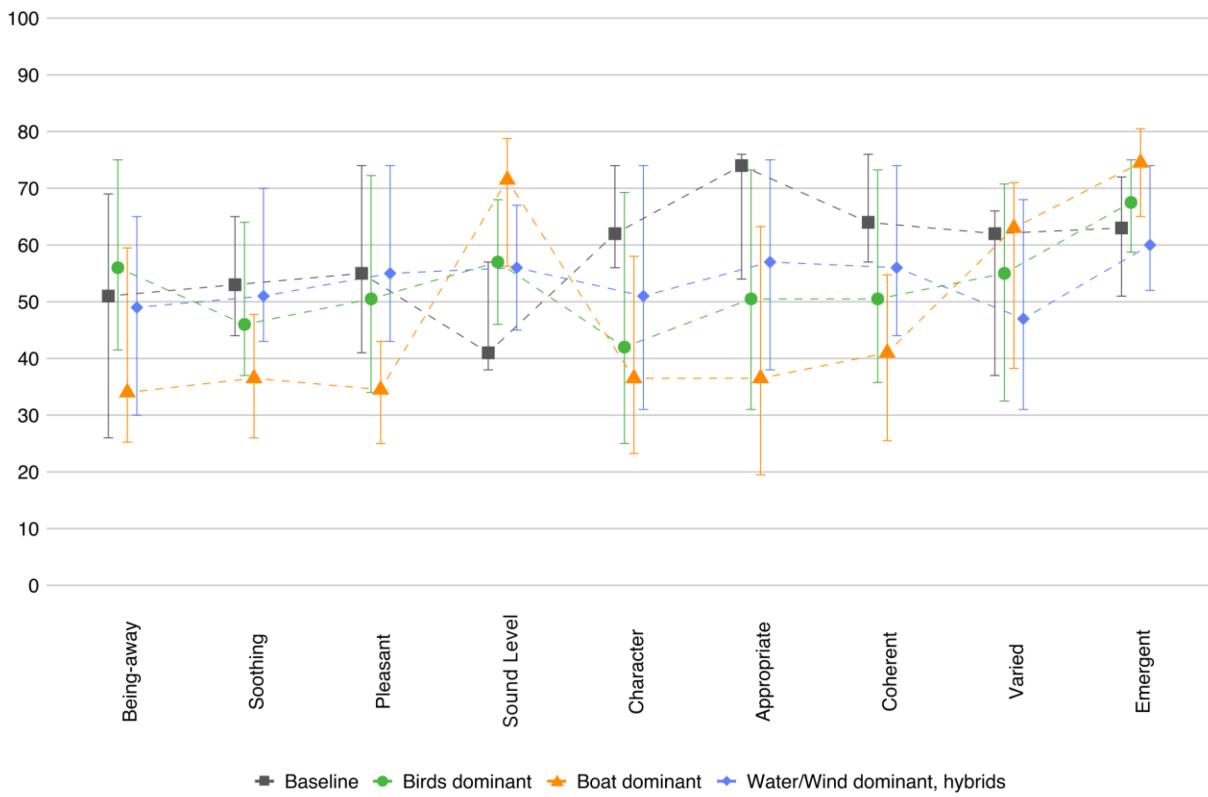


Figure 4.8. Soundscape ratings collapsed over groups of conditions: median, 25 and 75 percentiles (error bars).

Since the compositions and the associated perceived dominance of sound sources remain substantially different within each cluster, a finer grain comparison is necessary to properly characterize the impact of the different compositions on soundscape evaluation. In the following sections, we report on pairwise comparisons between the Baseline condition and the different compositions for each semantic scale, within each cluster of conditions identified in the previous section.

4.3.3.1. Compositions with a dominance of bird sounds

For the *Birds dominant* conditions, boxplots are shown in Figure *4.9* while results of the comparisons with the Baseline condition are shown in Table 4.8. Together, they reveal that Birds, Seagulls and Cormorant/Mast led to a decrease in the soundscape's character, appropriateness and coherence, Birds and Cormorant/Mast to an increase in perceived sound level, while Seagull and Cormorant/Mast led to a more emergent soundscape. The condition Sparrow did not lead to significant differences when compared to the Baseline, despite moderate effect sizes and a p-value between .05 and .1 suggesting that this excerpt led to a more pleasant (r = .50) and soothing (r = .49) soundscape.

4.3.3.2. Compositions with a dominance of water/wind sounds and hybrid

For the *Water/Wind dominant, hybrids* conditions, boxplots are shown in Figure 4.10 while results of the comparisons with the Baseline condition are shown in Table 4.9. Together, results reveal that Waves/Horn, Waves/Sparrow and Waves/Seagulls led to a less appropriate soundscape, that Waves/Horn also modified the character of the space and increased the perceived sound level, while Waves also led to an increase in the perceived sound level. While not reaching statistical significance, effect sizes and p-values between .05 and .1 suggest that Waves also led to a soundscape that is less prone to being-Away (r = .39), modified the character of the space (r=.39), and was perceived as less appropriate (r=.50) and coherent (r=.39). Similarly, moderate effect sizes and p-values suggest that Waves/Horn and Waves/Seagulls also led to a less coherent soundscape (r=.46 and r=.47, resp.). Otherwise, we did not detect any effect of the Waves/Wind condition on soundscape scales.

4.3.3.3. Compositions with a dominance of boat sounds

For the *Boat dominant* conditions, boxplots are shown in Figure 4.11 while results of the comparisons with the Baseline condition are shown in Table 4.10. Together, they show that both Boat and Horn condition strongly affected the existing soundscape, leading to a less pleasant, louder and more emergent soundscape, while modifying the character of the space, and leading to a less appropriate and more chaotic soundscape. Boat also led to a less soothing soundscape while effect sizes and a p-value between .05 and .1 suggest that Horn also led to a less soothing soundscape (r=.40).

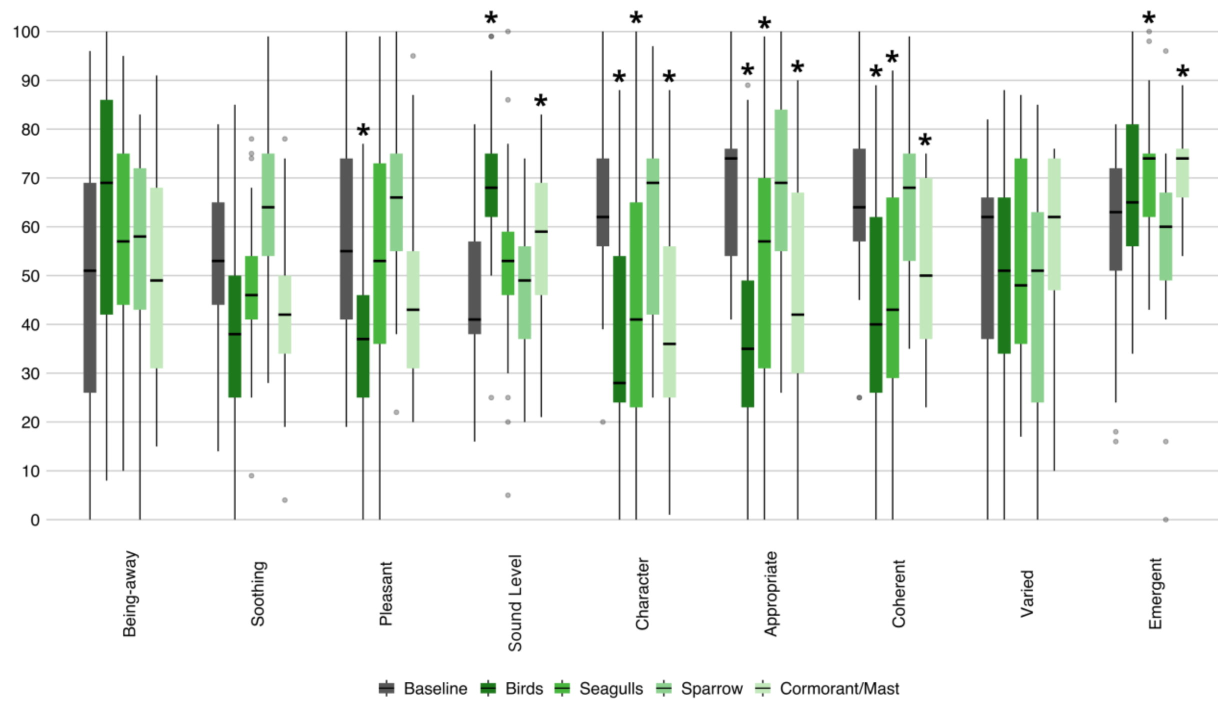


Figure 4.9. Birds dominant group: Boxplots for the soundscape ratings. Stars indicate a statistically significant difference when compared to the Baseline condition (p<.05).

	Birds		**Seagull**		**Sparrow**		**Cormorant/Mast**	
	p	**r [CI]**	**p**	**r [CI]**	**p**	**r [CI]**	**p**	**r [CI]**
Being-away	.14	.32 [0.03;0.66]	.15	.34 [0.04;0.68]	.29	.31 [0.02;0.69]	.93	.03 [<.01;0.45]
Soothing	.14	.33 [0.03;0.67]	.54	.16 [<.01;0.54]	.069	.50 [0.15;0.77]	.11	.36 [0.03;0.66]
Pleasant	**.048**	**.45 [0.12;0.74]**	.74	.06 [<.01;0.48]	.069	.49 [0.17;0.78]	.15	.32 [0.02;0.65]
Sound Level	**.001**	**.75 [0.56;0.87]**	.15	.34 [0.03;0.68]	.42	.24 [<.01;0.63]	**.026**	**.48 [0.15;0.78]**
Character	**.001**	**.72 [0.42;0.87]**	**.012**	**.60 [0.32;0.79]**	.44	.22 [<.01;0.61]	**.010**	**.59 [0.26;0.82]**
Appropriate	**.001**	**.75 [0.53;0.87]**	**.012**	**.65 [0.36;0.85]**	.68	.13 [<.01;0.53]	**.010**	**.61 [0.32;0.83]**
Coherent	**.004**	**.62 [0.32;0.82]**	**.013**	**.57 [0.26;0.81]**	.90	.03 [<.01;0.47]	**.021**	**.52 [0.18;0.79]**
Varied	.59	.11 [<.01;0.47]	.74	.09 [<.01;0.51]	.28	.33 [0.03;0.67]	1.00	<.01 [<.01;0.43]
Emergent	.39	.17 [<.01;0.54]	**.024**	**.51 [0.16;0.78]**	.83	.06 [<.01;0.45]	**.010**	**.60 [0.29;0.84]**

Table 4.8. Birds dominant group: Statistical significance in the change of the soundscape ratings with the compositions when compared to the baseline: Benjamini-Hochberg Wilcoxon signed-rank exact tests (grey cases: p <.1; bold text: p <.05), r effect size estimate and associated 95% confidence interval based on percentile interval bootstrap (N=1000).

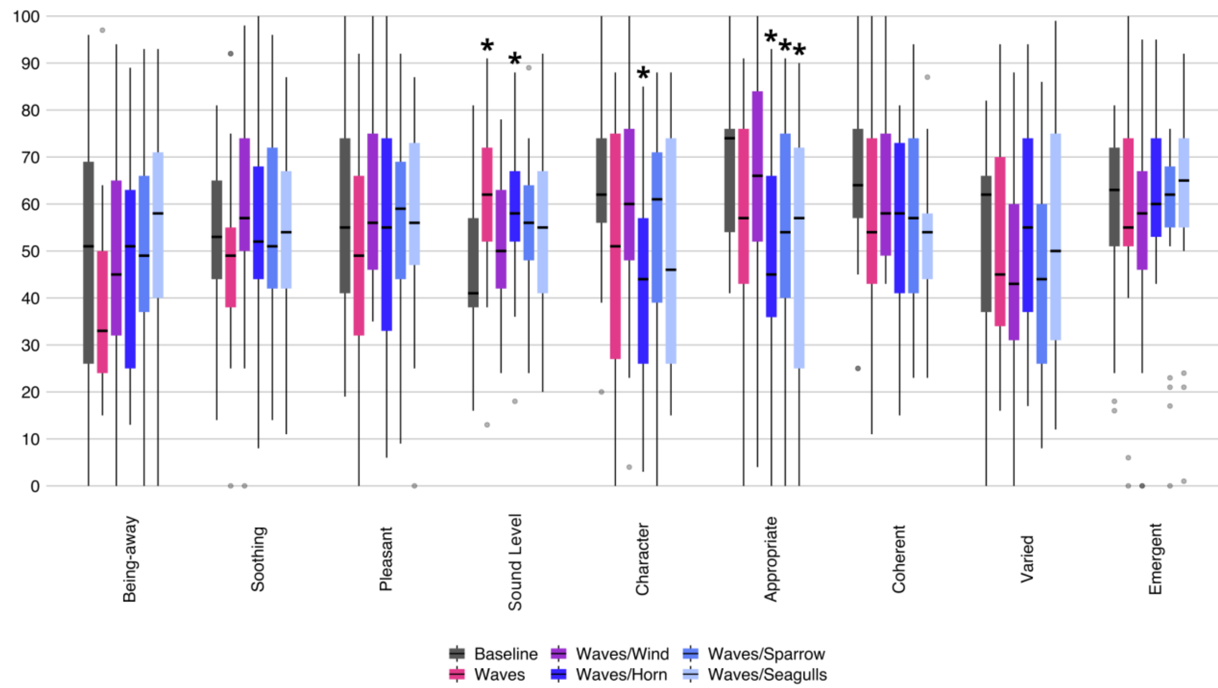


Figure 4.10. Water/Wind dominant, hybrids group: Boxplots for the soundscape ratings. Stars indicate a statistically significant difference when compared to the Baseline condition (p<.05).

	Waves		**Waves/Wind**		**Waves/Horn**		**Waves/Sparrow**		**Waves/Seagulls**	
	p	**r [CI]**	**p**	**r [CI]**	**p**	**r [CI]**	**p**	**r [CI]**	**p**	**r [CI]**
Being-away	.097	.39 [0.06;0.73]	.92	.03 [<.01;0.45]	.90	.04 [<.01;0.46]	.80	.08 [<.01;0.46]	.67	.13 [0.01;0.50]
Soothing	.37	.21 [0.01;0.58]	.31	.33 [0.01;0.58]	.90	.06 [<.01;0.45]	.80	.06 [<.01;0.46]	.67	.10 [<.01;0.51]
Pleasant	.26	.27 [0.02;0.62]	.31	.26 [0.01;0.64]	.90	.10 [<.01;0.50]	.80	.06 [<.01;0.44]	.67	.09 [0.01;0.50]
Sound Level	**.033**	**.60 [0.29;0.84]**	.31	.28 [0.02;0.60]	**.016**	**0.56 [0.23;0.80]**	.093	.50 [0.14;0.80]	.13	.39 [0.03;0.72]
Character	.097	.39 [0.05;0.68]	.52	.19 [0.01;0.60]	**.006**	**.64 [0.37;0.83]**	.58	.20 [0.01;0.59]	.13	.39 [0.05;0.69]
Appropriate	.060	.50 [0.15;0.76]	.31	.28 [0.02;0.66]	**.004**	**.70 [0.44;0.87]**	**.037**	**.58 [0.23;0.81]**	**.047**	**.56 [0.26;0.80]**
Coherent	.097	.39 [0.08;0.71]	.31	.24 [0.02;0.60]	.051	.46 [0.15;0.74]	.32	.32 [0.02;0.65]	.083	.47 [0.12;0.75]
Varied	.42	.16 [<.01;0.56]	.31	.27 [0.02;0.60]	.90	0.03 [<.01;0.46]	.53	.24 [0.01;0.57]	.67	.09 [<.01;0.57]
Emergent	.37	.24 [<.01;0.64]	.24	.44 [0.09;0.74]	.84	.15 [<.01;0.51]	.80	.13 [<.01;0.53]	.67	.09 [<.01;0.47]

Table 4.9. Water/wind dominant, hybrids group: Statistical significance in the change of the soundscape ratings with the compositions when compared to the baseline: Benjamini-Hochberg Wilcoxon signed-rank exact tests (grey cases: p <.1; bold text: p-values <.05), r effect size estimate and associated 95% confidence interval based on percentile interval bootstrap (N=1000).

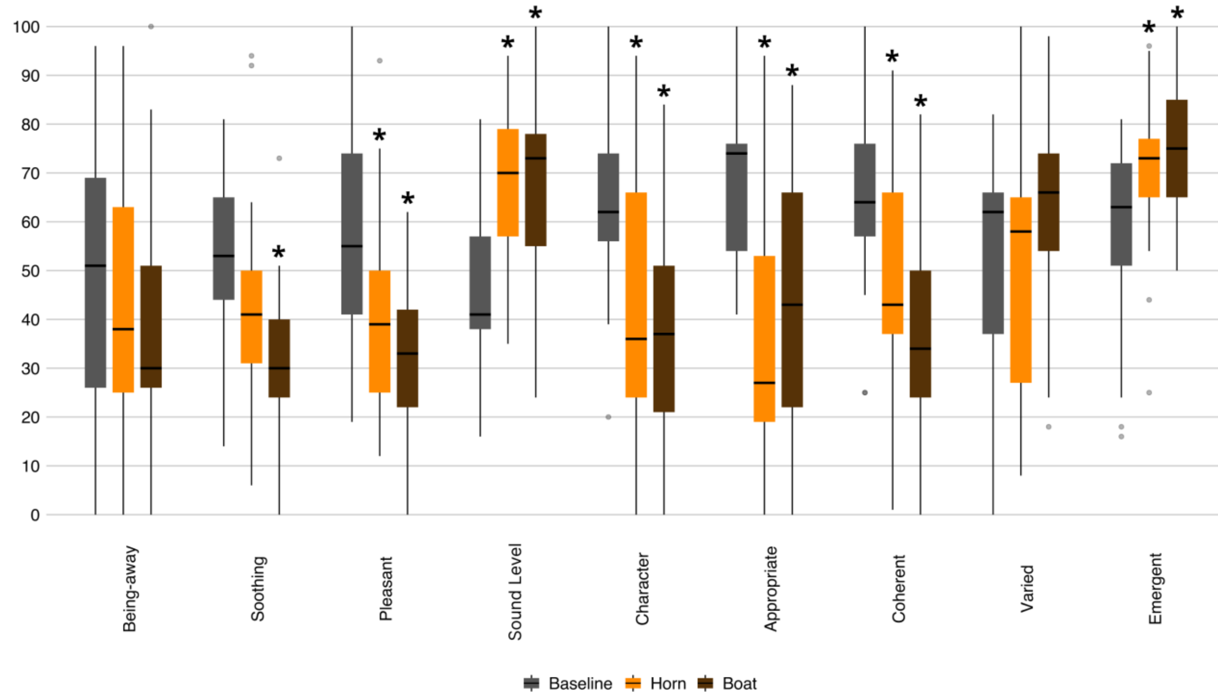


Figure 4.11. Boat dominant group: Boxplots for the soundscape ratings. Stars indicate a statistically significant difference when compared to the Baseline condition (p<.05).

	Horn		**Boat**	
	p	**r [CI]**	**p**	**r [CI]**
Being-away	.24	.26 [0.02;0.69]	.17	.29 [0.02;0.69]
Soothing	.071	.40 [0.05;0.73]	**<.001**	**.70 [0.45;0.87]**
Pleasant	**.017**	**.52 [0.18;0.80]**	**<.001**	**.74 [0.55;0.88]**
Sound Level	**.001**	**.72 [0.49;0.88]**	**<.001**	**.73 [0.53;0.86]**
Character	**.014**	**.54 [0.17;0.80]**	**<.001**	**.74 [0.50;0.88]**
Appropriate	**.001**	**.73 [0.53;0.86]**	**<.001**	**.82 [0.69;0.88]**
Coherent	**.014**	**.55 [0.23;0.81]**	**<.001**	**.77 [0.60;0.88]**
Varied	.50	.13 [0.01;0.48]	.17	.30 [0.01;0.48]
Emergent	**.050**	**.44 [0.09;0.73]**	**<.001**	**.69 [0.44;0.85]**

Table 4.10. Boat dominant group: Statistical significance in the change of the soundscape ratings with the compositions when compared to the baseline: Benjamini-Hochberg Wilcoxon signed-rank exact tests, r effect size estimate and associated 95% confidence interval based on percentile interval bootstrap (N=1000).

4.3.4. Significant moments and follow-up interviews

4.3.4.1. Overview of the significant moments

As explained in Section 4.2.3.2, each significant moment corresponds to one participant for one condition: when conditions are collapsed (for example for moments related to sounds present in the Baseline), several moments can correspond to the same participant. In the following sections, N represents the number of participants and M the number of moments involved for a given category. During the experiment, 22 participants identified 161 significant moments. An overview of the nature, valence and desirability associated to each moment in the follow-up interviews is provided in Table 4.11. Significant moments were most often associated with specific sound events (M=138) from the sound installation (Added sounds, M=91) or the Baseline (Background, M=47) than with an overall impression of the existing soundscape or of a combination of sound events from the Added Sounds and the Baseline (Overall, M=22).

Significant moments more often elicited a positive or negative valence than a neutral one (negative: M=69, positive: M=57, neutral: M=35), although participants were most often able to determine whether they would be willing to hear a neutral valence moment in the public space (no: M=83, neutral: M=10, yes: M=68).

	Valence			Desirability			
Reason	Negative	Neutral	Positive	No	Neutral	Yes	Total
Added sounds	35 (17)	20 (11)	36 (16)	44 (18)	5 (5)	42 (18)	91 (21)
Background	24 (13)	11 (8)	12 (7)	29 (15)	4 (4)	14 (8)	47 (18)
Overall	10 (7)	4 (4)	9 (6)	10 (7)	1 (1)	12 (8)	23 (11)
Total	69 (21)	35 (13)	57 (18)	83 (22)	10 (8)	68 (19)	161 (22)

Table 4.11. Number of significant moments identified during the experiment according to their reason and associated valence and desirability during follow–up interviews. In brackets is the number of participants involved.

4.3.4.2. Moments associated with the Baseline

Moments associated with the Baseline sound environment are shown in Figure 4.12. They were often related to traffic noise (M=19) at two periods in the Baseline recording in which trucks and motorbikes are passing-by (e.g., *"the motorcycle, yeah, the vehicle that rumbles, that's what strikes me"*), described as unpleasant (N=5), stressful or uncomfortable (N=3), and/or disruptive (N=4, e.g., *"it's an emergent noise that's not necessarily pleasant, and for me, it disturbs the global ambiance"*). Two other sound events were often mentioned, with neutral to positive connotations: an audible voice towards the end (M=10; N=5) often noticed because it was the only audible voice (e.g., *"it was just the first time when I heard the human voice talking"*), and the sound of someone passing by with a shopping cart (M=9; N=5) which raised interrogations about its origin (e.g., *"the little metallic noise that I identified, so every time I heard it, I was hooked, wondering what it was."*).

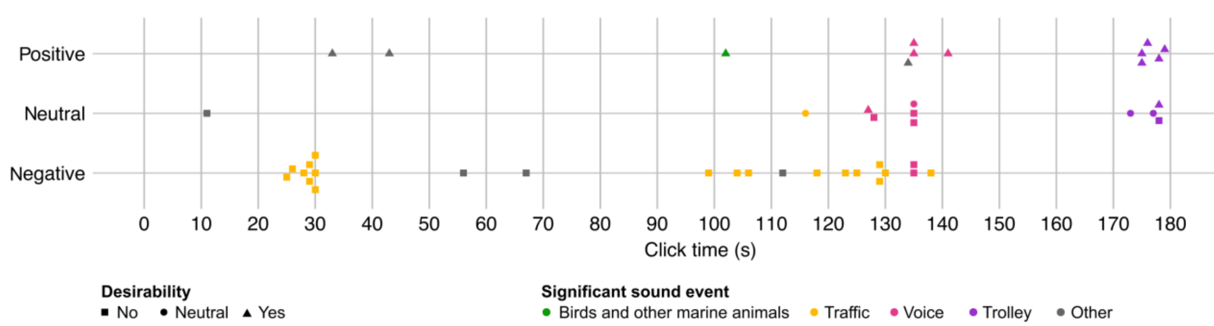


Figure 4.12. Significant moments related to the Baseline: nature of the sound that led the participants to identify a significant moment and valence associated to it in relation to the position of the moment in the Baseline.

4.3.4.3. Moments associated with the compositions

Moments associated with the Added Sounds can be grouped into 5 broad categories, displayed in Figure 4.13 and described as follows:

Birds and other animals (M=32; N=15) – most often identified in the Bird dominant conditions (see Figure 4.13). They were either associated with individual species (M=21), or with birds sounds (M=11), usually positively connotated (M=17), described for instance as pleasant (N=4) and soothing (N=2, e.g., *"I loved this moment. I like the birds singing and all. I find it super soothing, super relaxing."*), and enjoyed for their evocative potential (N=7, see Section 4.3.4.4). Neutral connotations (M=9) were related to the unexpected/unidentifiable nature of the sounds (N=4, e.g., *"I was just wondering what kind of bird it was, whether it was a duck or something and why does it make that sound because I don't think it's a normal sound for a bird."*) or because of the potential for these sounds to be disruptive on site (N=2). Finally, a few moments with birds and animals were also negatively connotated (M=6), especially in the Birds (M=3) and Seagulls (M=2) conditions, because they were perceived as being too loud or overwhelming (N=3), inappropriate (N=2), or disruptive (N=3, e.g., *"I don't really understand the noise of the birds, the gulls, or whatever, because I don't think they belong there. I wouldn't like to see so much noise in the park. It would be, it would be disturbing."*). Overall, some bird species tended to be preferred over others. Some were unilaterally appreciated, such as the sparrow present in the Sparrow and the Water/Sparrow condition (M=6, e.g., *"It's a different bird [...] that's more pleasant to me than a seagull, for instance."*), while others provoked divided opinions such as the seagulls (positive: M=5, neutral: M=1, negative: M=3). Otherwise, birds and animal sounds that were least expected (cormorants and seals) were often (mis)identified with animals plausible in the existing space (e.g., frogs for the cormorant and a weeping dog for the seal), causing surprise but no strong emotional reactions (e.g., *"there's like no frog there, or at least I wouldn't expect to see frogs there, so maybe it's more of a surprise effect. I can't say it's unpleasant, but it's more the surprise of hearing it."*).

Horn (M=24; N=16) – related to the boat horn and clustered around the times in which it was played: once at the beginning of the Horn condition (M=15); and twice during the

Waves/Horn condition (M=3 and M=6, respectively). During the Horn condition, this sound was most often associated with a negative valence and perceived as not desirable (for 13 out of 15 participants). It was often perceived as unpleasant, disruptive or disturbing (N=8, e.g. *"so I thought that, well, the horn was a bit of a mood breaker."*), but also too close, too loud or even overwhelming (N=4, e.g., *"this is like, the boat is going through, I don't know. [The adjacent street] or something, you know? So it's very surprising that it's so close."*), and sometimes associated with traffic noise (e.g., *"adding additional horn, even if the sound doesn't really travel too far, it's, it's adding to maybe just the overall traffic, [...] It is a traffic noise, it's sea traffic, but it's still traffic"*). The participants that enjoyed this moment mention the evocative power of this sound (N=3, e.g., *"it's quite positive because we have a picture of a boat, the sea..."*). During the Waves/Horn condition, opinions are more divided, mainly because the sound was less loud in this condition which made it more acceptable for some participants (4 out of 9 participants perceived it as desirable). Participants that liked it described it as pleasant (N=3) or soothing (N=2), while other participants disliked it because it was disruptive (N=2).

Public announcement and boat engine (M=15; N=15) – related to these two sounds present in the Boat condition. The public announcement (M=11) was unilaterally perceived negatively and not desirable (for 10 out of 11 participants) because it was unexpected or unintelligible (N=4, e.g., *"well, again surprised, like how come this sound is there because there's no [...] metro station or supermarket close by that you would expect this to hear."*), disruptive (N=3), or overall unpleasant (N=4). Noise from the boat engine was identified once and perceived as oppressive.

Water/Wind (M=14; N=10) – associated with water or wind sounds (2 of which were associated to the combination of Water/Wind and birds), most often across Water/Wind dominant and hybrid conditions. Moments related to these sounds were mostly positively connotated (M=11 moments) and desirable (M=12) and perceived as pleasant (N=5), soothing (N=3), or enjoyed for their potential to mask background noise (N=2, e.g., *"the water sounds caught my attention, they are soft but pleasant and distract me from the hum of traffic."*). A few moments were perceived as neutral, either because they were unexpected (N=2) or did not provoke a strong emotional reaction (N=1). Otherwise, six participants reported during the interviews that they struggled to differentiate between Water and Wind sounds while five participants also reported a confusion between Water/Wind sounds and traffic noise (e.g., *"at the very beginning, the first time I heard [the water sound], [...] I really had the impression that it was like a train going by continuously, then it took me a little while to realize that it was [...] the sound of the sea"*).

Mast (M=6; N=6) – sound of a cable hitting a boat mast, present in the first half of the Cormorant/Mast condition. When identified, this sound was more often perceived as negative and not desirable (for 4 out of 6 participants), mostly because it was perceived as too repetitive and/or difficult to identify (N=3, e.g., *"this clicking sound, it could be annoying because you don't really know where it's coming from, and it's quite repetitive"*), although another participant found it to be soothing.

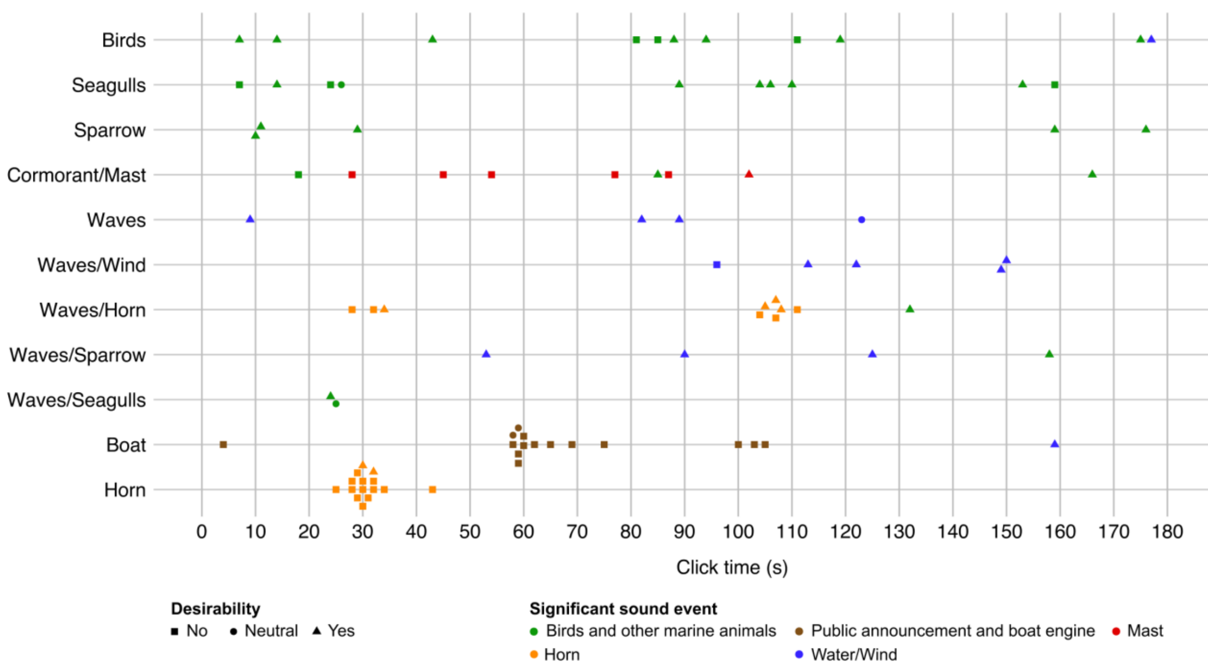


Figure 4.13. Significant moments related to the Added Sounds: nature of the sound that led the participants to identify a significant moment and valence associated to it in relation to the position of the moment in the excerpt. For each condition, each moment is associated to a unique participant since participants were only exposed once to each condition.

4.3.4.4. Associations and representations

Throughout the interviews, participants linked the added sounds with a broad diversity of sceneries and sound sources—in total, 29 different types of associations were identified—which did not always correspond to the true nature of the sounds present in the compositions. For instance, while seagulls were associated with beaches (N=2), ports (N=2), the sea (N=3) or the nearby river (N=1), three participants associated them with Canada geese migrating, and the nostalgic feeling of passing time, while two other participants with the presence of garbage that attracts these birds. Some associations could be even more exotic, for example the seals and birds together were associated with a tropical rainforest by one participant, and with a farm by one another. Otherwise and as we have seen in Section 4.3.4.3, some participants tried to link the added sounds with sources that would be more plausible to hear in the public space: cormorants were thought to be frogs (N=2), seals to be weeping dogs (N=2), the boat's public announcement to come from the nearby metro station (N=3), or the boat horn to be a truck horn (N=2). These associations relate to the participants' past experience and highlight how evocations will inevitably diverge from the installation's initial goals to evoke the sea. Further, these evocations sometimes had a strong impact on participants' perception: for instance, a participant had a strong aversion towards the sound of a cable hitting a boat mast in the Cormorant/Mast condition because they were exposed to this sound a lot in their life, while another enjoyed the Boat horn because they used to live close to a port and were nostalgic of this specific sound.

4.3.4.5. Relationships between the added sounds and the background noise

Nine participants mentioned that some added sounds heard during the experiment had the potential to mask or distract from traffic noise, be it Wind (N=3), Water (N=5), or Bird sounds (N=5, e.g., *"we've got the same annoying motorcycle noise, but the seagulls bring a more pleasant atmosphere."*). Otherwise, five participants mentioned a notion of harmony between sources from the sound installation and the background sound environment (e.g., *"I like this [...], the harmony again between the birds [...] and the car"*), while another participant mentioned a strong disharmony between the birds and the truck.

4.4. Discussion

4.4.1. Synthesis of findings

The different compositions elicited a wide range of evaluations and reactions, from more soothing and pleasant soundscapes (e.g. with Sparrow) to strong decreases in the soundscape's pleasantness and familiarity (e.g. with Boat). An analysis of the perceived dominance of sound sources over the 11 compositions allowed to identify three clusters of conditions: *Birds dominant* conditions, *Water/wind dominant, hybrid* conditions, and *Boat dominant conditions*, which served as a framework for analyzing the effects of the different compositions when compared to the Baseline sound environment.

With the exception of Sparrow which led to an increase in ratings for Pleasant and Soothing, *Bird dominant* conditions had strong effects on the soundscape's familiarity, with a significant reduction in ratings for Character, Appropriate and Coherent. Two compositions also led to an increase in perceived sound level (Birds and Cormorant/Mast) and Birds a decrease in pleasantness. Although follow-up interviews show that bird sounds were overall appreciated, some species such as Sparrows were unanimously favored while others such as Seagulls were more debated. Otherwise, species that were obviously non-native to the area (Cormorants, Seals), were sometimes perceived as incongruent or surprising. These results complement previous research and show that the potential impact of bird (and other animals) sounds on soundscapes is related to the involved species (Jeon et al., 2010; Zhao et al., 2020), but also to their congruence with the context (Franěk et al., 2019; J. Y. Hong, Lam, et al., 2020).

The effects of *Water/Wind dominant, hybrid* conditions were more subtle, with Waves, Waves/Horn, Waves/Sparrow and Waves/Seagulls reducing ratings for familiarity (Character, Appropriate, and/or Coherent) and Waves, Waves/horn and Waves/Sparrow increasing the perceived sound level. Otherwise, we did not detect significant effects of

Waves/Sparrow on soundscape ratings. Follow-up interviews reveal that when identified as significant, water and wind sounds were mostly positively connotated and reportedly led to more desirable, pleasant, or soothing soundscapes. However, participants also reported confusing water or wind sounds with traffic sounds—hence the relatively low perceived dominance of wind and water sounds throughout the study—and sea wave sounds were sometimes perceived as incongruent. The confusion between water/wind sounds and traffic noise have been previously reported, and might be related to the water and wind sounds' specto-temporal characteristics in relation to those of the traffic noise (Axelsson et al., 2014; Hellstrom et al., 2014; Rådsten Ekman et al., 2015), as well as the absence of a visual context suggesting the presence of water (J. Y. Hong, Lam, et al., 2020). This might also be related to the high temporal variability of the Baseline traffic noise: the number of significant moments it elicited shows that it drew auditory attention, potentially modulating the perceived dominance and positive influence of water or wind sounds (see De Coensel et al., 2011).

Boat dominant conditions led to a strong alteration of the Baseline soundscape, reducing ratings for variables related to pleasantness (Pleasant and Soothing), familiarity (Character, Appropriate, and Coherent) while increasing the perceived sound level and emergence. Follow-up interviews show that sounds related to boat traffic (boat horn, public announcement, mast) drew significant attention, but were perceived as highly incongruent or disruptive and were sometimes identified as additional traffic noise. Some participants still recognized and appreciated the evocative power of boat horns. This provides evidence that highly evocative sounds, are at the risk of decreasing the overall soundscape quality when deemed incongruent, rather than providing psychological restoration by improving the sense of Being-Away (Payne, 2013). Further, this highlights the challenges of transporting the most culturally significant soundmarks or keynotes from one space to another (see Schafer, 1977; Parker & Spennemann, 2022).

To summarize, the different compositions mostly affected the soundscape's familiarity (Appropriate, Character and Coherence) and the most evocative sounds (e.g., boat horn, seagulls, cormorants) were also perceived as less appropriate, if not disruptive. Results also show that a tight balance has to be struck between traffic noise and the added sounds: the compositions often increased the perceived sound level, did not seem to affect the perceived dominance of traffic noise (some participants even reported that the added sounds were perceived as additional traffic), and sometimes masked non-dominant sound sources such as the bird sounds present in the Baseline, or sounds from passers-by. Although many studies report on the energetic or attentional masking of traffic noise by water or bird sounds (e.g., Lee & Lee, 2020; Hong, Ong, et al., 2020; Deng et al., 2024), our results are consistent with the more nuanced findings on the effects of water sounds in urban environments exposed to small to medium roads' noise (De Coensel et al., 2011; Axelsson et al., 2014; Trudeau et al., 2020), or on the effects of sound art with an auditory texture similar to the pre-existing sound environment (Hellstrom et al., 2014). This also confirms previous field observations that sound installations—which are typically not designed to dominate a soundscape, nor as energetical maskers—are more likely to mask non-dominant sounds than dominant ones (Fraisse, Tarlao, et al., 2024). Further investigation is required on this matter, regarding for instance the temporal features of traffic noise (see Morel et al., 2012), signal-to-noise ratio of the added sounds (e.g., Hong, Ong, et al., 2020), or psychoacoustic features such as saliency (e.g., see Filipan et al., 2019; Bouvier, 2024). Otherwise, the different sounds elicited a wide variety of associations and representations, which at times had a strong impact on participants' perceptions: the same sound could be triggering for some people but nostalgic for others. These associations can be considered as evidences of *anamnesis* (Augoyard & Torgue, 2006), and highlight the critical role of past experience and interindividual differences in the evaluation of unfamiliar sounds.

4.4.2. Methodological implications

In this study, the soundscape simulation tool was used to compare different soundscape interventions (Fraisse, Schütz, et al., 2022). Compared to a previous study (see Fraisse, Schütz, et al., 2024), it was modified so that each composition was presented over the same loop rather than a randomly generated background sound environment. Although commonly used for comparing soundscape interventions in repeated-measures designs (e.g., Hong, Ong, et al., 2020; Deng et al., 2024; Calarco & Galbrun, 2024), our study shows that this repetition may reduce the background environment's validity when it has a high temporal variability: significant moments reveal that the Baseline loop had a clear narrative and 7 participants reported noticing repetitions between the conditions. Further, the Baseline loop was only representative of *Parc des Madelinots'* average level of activity, and the removal of intelligible voices was often noticed: 19 participants reported that they heard fewer human sounds during the experiment compared with their memories of the place. Otherwise, the protocol did not allow to evaluate the influence of prolonged exposure of public space users to the installation, the influence of visual cues (J. Y. Hong, Lam, et al., 2020) or other sensory modalities.

The proposed soundscape scales were informed by previous research using a soundscape simulation tool to evaluate a public space sound installation in Paris (Fraisse, Schütz, et al., 2024), while the perceived sound source scales were derived from the ISO 12913-2:2018 (ISO TS 12913-2, 2018). Overall, the different compositions mostly impacted the soundscape's *familiarity*—Appropriate, Character, and Coherence. This provides further evidence that this dimension is critical to evaluate how sound installations can reshape or reconfigure urban soundscapes (Lacey, 2016b), and that a model solely based on pleasantness and eventfulness as featured in the ISOs 12913-2:2018 and 12913-3:2019 might be incomplete to assess sound installations and/or situations with unconventional or unfamiliar sounds. Otherwise, we were not able to characterize the restorative potential of any of the compositions, as we did not detect any effect on the Being-Away scale apart from a decrease observed with the Waves composition. This suggests that this feature of restorativeness might be difficult to estimate in laboratory settings, likely because it requires some level of abstraction from the participants. Incidentally, we could not detect significant effects in situations where the effect sizes were small to moderate. This indicates a potential lack of statistical power due to the sample size, constrained by the inclusion criteria requiring familiarity with *Parc des Madelinots*.

We would also like to highlight the productivity of identifying significant moments during soundscape evaluation, and describing them back during follow-up interviews. The identification of significant moments provided an insightful snapshot of the elements in the soundscape that marked participants or drew their attention, regardless of their nature. The reactivated listening allowed to characterize the meanings, feelings, and associations related to these significant moments, without interfering with soundscape evaluation (as could occur in a think-aloud protocol, see Baxter et al., 2015). Ultimately, the use of significant moments enabled an excerpt-by-excerpt interpretation of the soundscape evaluations, which is crucial to derive design guidelines for the composer. Altogether, the interviews provided a more nuanced feedback than the scale ratings alone and showed that participants tended to reach consensus more easily when evaluating least preferred compositions or sounds (e.g., Boat) than preferred ones (e.g., Sparrow), a trend already observed in previous research (Fraisse, Schütz, et al., 2024). Further, the interviews enabled us to identify phenomena that span multiple experimental conditions, such as the associations and representations elicited by certain sound sources, or the frequent confusion between water sounds, wind sounds and traffic noise.

Overall, the present study highlights the need for complementing the existing tools provided by the ISO/TS 12913 series in light of the current efforts to establish standardized guidelines to implement soundscape interventions (*ISO/AWI TS 12913-4*, 2023), especially by including evaluations for soundscape familiarity. This study further demonstrates the importance of triangulating closed- and open-ended data in the evaluation and comparison of soundscape interventions (ISO TS 12913-2, 2018; Botteldooren et al., 2023; Fraisse, Schütz, et al., 2024), and demonstrates the productivity of using significant moments when prototyping a soundscape intervention in laboratory settings.

4.4.3. Practical implications for the design of the sound installation

This study was part of a greater research-creation collaboration to inform the composition of the *Les Madelinéennes* sound installation with soundscape evaluations. Laboratory settings allowed the composer (the second author) to freely explore different combinations of sounds relevant to the installation's intentions: to provide a more pleasant and soothing soundscape to *Parc des Madelinots*, while encouraging disconnection by evoking a maritime environment.

Results showed that a compromise has to be found between these different goals: traffic noise is dominating the existing sound environment, and its combination with the most evocative sounds (such as boat sounds or seagulls) might lead to an inappropriate, loud, or even disruptive sound environment. As part of the research-creation, a detailed report of the study including an excerpt-to-excerpt analysis was provided to the composer, together with a set of design guidelines. These guidelines allowed to inform a new iteration of the sound installation to be deployed in 2025: they resulted in a simplification of the composition with less evocative soundmarks (almost no boat sounds, less seagulls, seals, or cormorants), and a reworking of the water and wind sounds to minimize the risk of confusion with traffic noise. Despite the nuanced results, the experiment demonstrated the potential for the sound installation to help revitalize the public space and was well received by the local community. Notably, 17 participants mentioned their willingness to spend more time in the park in the presence of the sound installation. Further directions in this project include a field evaluation of the sound installation.

While we believe that these outcomes might be transferred to other sound installations and situations, they are closely related to site-specific characteristics. We advocate for the use of similar methodologies for the design and evaluation of public space sound installations throughout the creative process (see Fraisse, Wanderley, et al., 2024), to better improve the everyday experiences of public spaces.

4.5. Conclusion

In this laboratory study, we evaluated composition sketches of a coastal-themed permanent sound installation to inform its composition and investigate the soundscape effects of transposing coastal soundmarks to an urban area.

Consistent with previous research, our study confirms that sound installations can alter the familiarity of soundscapes and mask non-dominant sounds. Otherwise, water and wind sounds had nuanced effects because they risked being confused with the background traffic noise; the impact of bird sounds was highly species-dependent, while boat sounds, despite their evocative potential, were generally disruptive. Additionally, the experiment elicited many idiosyncratic associations with the participants, reflecting manifestations of anamnesis.

Our findings further support the use of soundscape scales related to familiarity alongside standard soundscapes scales. However, we were unable to demonstrate the productivity of scales pertaining to being-away, questioning their applicability in laboratory settings. The study also highlights the benefits of triangulating soundscape scales with follow-up interviews and demonstrates the productivity of identifying and revisiting significant moments for qualitative characterization.

Beyond theoretical and methodological contributions, this study informed the next iteration of the sound installation, scheduled for deployment in summer 2024. Future work includes a field evaluation of the installation with the local community. Overall, we recommend using similar methodologies to inform the design of soundscape interventions, particularly for public space installations.

CHAPTER 5. DISCUSSION

Wherever we are, what we hear is mostly noise. When we ignore it, it disturbs us. When we listen to it, we find it fascinating.

John Cage,
Silence: Lectures and Writings.

Current research on added sounds in public spaces tends to focus on adding natural sounds or generic music, with a limited reflection on the sonic content itself or on the applicability of such practices. Conversely, sound artists have a natural interest in the reception and integration of their work into the existing soundscape, but often lack the resources to systematically evaluate it.

This dissertation aimed to extend the academic understanding of how sound installations can affect the human auditory experience of public spaces. Three research-creation projects with different sound artists provided new insights into how sound installations can affect everyday soundscapes. This research also led to the development of methodologies and the identification of best practices for evaluating and informing the design of sound installations through soundscape studies.

In this chapter, we delve into the theoretical, methodological, and practical perspectives that emerged from this research. Notably, we present a research-creation collaboration framework for designing and evaluating public space sound installations, which stands as the ultimate outcome of this research. Finally, we provide an overview of the limitations and perspectives for future works.

5.1. Theoretical insights

The human perception of everyday sounds is increasingly well understood, thanks to decades of multidisciplinary research on the matter (e.g., Augoyard & Torgue, 2006; Lavandier & Defreville, 2006; Guastavino, 2018; Ma et al., 2021; Bouvier, 2024; Gaver, 1993). Despite this growing body of research, the effects of sound installation art on soundscape are rarely considered in the scientific literature.

However, the study of sound installations can lead to unprecedented experimental situations. Sound art in public spaces generally seeks to diversify experiences by expanding the range of sounds typically heard in an urban context (Lacey, 2016b). While each artist has their own approach to this presumably common goal, this often results in the addition of unusual or unfamiliar sounds[8] to a pre-existing urban soundscape. The systematic study of public space sound installations is therefore conducive to the development of theory about the effects of added sounds on soundscapes. In this dissertation, the study of three sound installations in different contexts allowed to better understand how unusual sounds arising from an artistic approach can affect the auditory perception of urban sound environments.

An initial overview of results points to the presence of common effects of sound installations in public spaces. In chapter 2, we saw that four temporary sound

[8] Here, "unusual or unfamiliar sounds" refer to sounds that are different from those typically heard in everyday life in a given urban environment. This is context-dependent, as illustrated by the reported unfamiliarity of sounds transposed from one space to another in chapter 4.

installations overall enhanced the *in situ* experience of public space users, leading to calmer and more pleasant or less loud soundscapes. The laboratory studies presented in chapters 3 and 4 showed a different picture: if several composition prototypes led to more pleasant and soothing soundscapes in both studies, a consensus between participants would more easily emerge on the excerpts that they disliked than on those that they liked. In other terms, the laboratory evaluations were overall less positive and more negative than *in situ*, which might be related to the experimental settings (further discussion on this matter below; see Tarlao et al., 2022). Most importantly, the different compositions evaluated in laboratory settings greatly (and mostly) affected the soundscape's familiarity and perceived variety, confirming that sound installations are particularly prone to diversifying soundscapes, or "rupturing the everyday in global cities" (Lacey, 2016b, p.16). But the follow-up interviews in these studies also illustrated the challenges posed by attempting to diversify the existing soundscape: compositions or prototypes that resulted in the least familiar or most varied soundscapes were also more likely to be perceived as inappropriate, incongruent, or even disruptive. If these general observations show that there are common ways in which sound installations can affect public spaces, a closer look at the results reveals specific effects of the sound installations in relation to their associated composition strategy.

A main research hypothesis investigated in this dissertation concerned the relationship between the nature of added sounds and their propensity to be more noticeable, according to the conceptual division proposed by Livingston (2016) between *oppositional* (sounds that are clearly noticeable) and *backgrounded* (sounds that subtly blend into the existing environment) sound installations. Specifically, in chapters 2 and 3, we explored the relationship between the *abstract* / *referential* nature of the added sounds (see Fraisse et al., 2022) and their position within this *oppositional* / *backgrounded* continuum. Our intuition was that abstract sounds would be more salient or *oppositional* because of their unexpected nature, while referential sounds would be more integrated or *backgrounded* because of their morphology and less unexpected nature, particularly for familiar natural sounds (e.g., sparrows or fountains). This intuition was validated empirically. Of the four sound installations evaluated in chapter 2, the most abstract sound installation had the greatest impact on soundscape. Conversely, the soundscape effects of the composition sketches evaluated in chapter 3 on familiarity and variety was more pronounced for sounds involving deeper sonic abstractions, although the sketches perceived as being the most varied were ultimately those that contained the greatest diversity of sound events by combining abstract and referential sounds. Of course, this does not mean that referential sounds cannot be oppositional: for instance, some of the referential composition sketches presented in chapter 4 were perceived as highly unfamiliar and varied.

Another research hypothesis explored throughout the dissertation concerns the restorative potential of sound installation art. Soundscape studies have demonstrated that natural sounds tend to improve assessments of restorativeness or can favor psychological restoration following periods of stress and/or fatigue (Ratcliffe, 2021), but the restorative effects of public space sound art have yet to be investigated. In chapter 2, it was observed that the installation designed with a goal of promoting relaxation with a focus on natural sounds increased perceived restorativeness by enhancing the sense of being-away. However, we did not detect increases in ratings related to restorativeness (e.g., Soothing, Being-Away, Coherence) in the presence of sound art in chapters 3 and 4, except for a few exceptions (such as the sparrow sounds evaluated in chapter 4). Follow-up interviews in both studies bring more nuance and indicate that, although familiar natural sounds seem to have the most potential to be restorative, less familiar sounds (like the abstract composition sketches in chapter 3) or distinctive soundmarks (such as boat sounds in chapter 4) can also be restorative by evoking a sense of being transported elsewhere. The wide range of associations evoked by the added sounds in chapter 4 eloquently illustrate this potential (these associations also align with the concept of *anamnesis*, i.e. the involuntary revival of memory caused by listening, see Augoyard & Torgue, 2006). Nevertheless, the least familiar sounds were also more likely to be perceived as disruptive, which would in turn reduce the soundscape's restorativeness and pleasantness.

Another central issue explored in this dissertation is the phenomenon of *attentional* masking, where the presence of sound installations draws auditory attention away from other sound sources. The effect is also called informational or non-energetic masking in the soundscape literature (e.g., Hellström et al., 2014; Hong et al., 2020), but we chose to call it attentional masking to differentiate it from the physiological informational masking effect (see Amiri & Jarollahi, 2020), or inattentional deafness (see Dalton & Fraenkel, 2012). Overall, the three studies in this dissertation and particularly those detailed in chapters 2 and 4 (chapter 3 reports only indirect evidence) provide converging evidence for the potential of sound installations to mask environmental sounds. However, the masking effect was consistently observed on non-dominant sound sources, regardless of their associated valence: sound sources masked across chapters 2 and 4 include distant construction noise, air conditioners but also more pleasant sounds such as birds or voice. In contrast, traffic noise was generally not masked by the sound installations, whether in laboratory settings or real-world conditions, except when traffic volume was reduced (see chapter 2). These observations contrast with a majority of studies showing how natural sounds can mask dominant sound sources (e.g., Deng et al., 2024; Hong et al., 2020; Lee & Lee, 2020; Nilsson et al., 2010). Nevertheless, our findings align with the more nuanced results from Oberman and colleagues' (2020) laboratory study on sound installations, and several studies investigating the masking effects of water sounds amidst noise from smaller to medium-sized roads (Axelsson et al., 2014; De Coensel et al., 2011; Trudeau et al., 2020). Overall, our studies converge to demonstrate that sound installations tend to mask non-dominant sounds instead of dominant ones. This is consistent with the nature of artistic sound installations, which, unlike energetic masking interventions (e.g., Jeon et al., 2010), are typically not designed to dominate the sound environment but rather to subtly alter its perception. Of course, approaches vary widely among sound artists: for instance, we saw that Nadine Schütz's *Niches Acoustiques* involves complementing the existing sound environment by exploiting the *niches* effect (see Augoyard & Torgue, 2006), while Charles Montambault's *Les Madelinéennes* borrows the aesthetic and functional codes of ambient music (Eno, 1978).

To wrap up, our findings suggest a few commonalities (such as the masking of non-dominant sound sources and the strong influence of familiarity) and many specificities (for instance, the evaluated installations show various impacts in terms of pleasantness, perceived variety, noticeability, restorativeness, or evocations) in the way sound installations can affect public space soundscapes. This heterogeneity of effects is expected due to the inherently site-specific nature of sound installations (see Tittel, 2009) and the diversity of creative approaches and experiences. In addition, we showed in chapter 2 that the impact of a sound installation could also depend on contextual parameters such as space and time. Overall, the impact of sound installations on soundscapes is largely influenced by their composition and contextual factors. For this reason, creating a comprehensive theory that can accurately predict the impact of public space sound installations across various sites and artistic projects appears unfeasible, if even desirable. Rather, our research underscores the need for a replicable methodology that can help inform sound installations' design.

5.2. Methodological Perspectives

The different studies reported in this dissertation provide guidance on determining adequate measurement protocols to evaluate public space sound installations—and by extension soundscape interventions—in light of the current efforts to provide standardized guidelines for their implementation (ISO/AWI TS 12913-4, 2023).

I already discussed in the previous section the importance of evaluating the impact of sound installations on soundscape familiarity and variety. The matter is not only highly relevant for sound artists (Lacey, 2016b) but we provided evidence in chapters 3 and 4 that these soundscape dimensions are indeed strongly altered in the presence of sound art. To investigate familiarity, these studies show that a scale regarding appropriateness (to the space or to the activity, as proposed in the ISO 12913 series) could gain to be complemented with less connotated scales such as character and coherent (used across chapters 3 and 4), or familiarity itself (used in chapter 3). Since familiarity matters, it is also important to involve participants that have an existing relation to the site (e.g. local residents or workers). Otherwise, we demonstrated the relevance of scales related to variety, but further research is required to investigate the relationship between variety and eventfulness and their link with sounds from human activity (see Tarlao et al., 2023). Moreover, effects of sound installations on variety differed across chapters 3 and 4, highlighting the need for further investigation.

Another important point is the difference between the soundscape effects of the installations on site (chapter 2) and in laboratory settings (chapters 3 and 4): all the installations evaluated in chapter 2 had a positive influence on soundscape (e.g., increase in calmness and reduction in perceived loudness), especially in the presence of construction noise. In contrast, the two installations evaluated in chapters 3 and 4 did not seem to affect the soundscape pleasantness and were more at risk to increase the perceived loudness, despite follow-up interviews indicating their potential to improve the soundscape in both experiments. If the difference could be partially explained by the nature of the involved compositions (which were not end-products but composition sketches sometimes very different from the installations to be deployed), previous comparisons between in situ and laboratory evaluations can provide leads as to why this happened. Research on this matter showed that soundscape evaluations tended to be less positive and more negative in laboratory settings, potentially because of the absence of other stimuli such as the visual environment which could alleviate the unpleasantness of urban noises (Cadena et al., 2017; J. Y. Hong, Lam, et al., 2020), or maybe because people expect cities to be noisy and might employ coping strategies in daily life (Tarlao et al., 2021). Similarly, soundscapes were shown to be perceived as louder in laboratory settings than *in situ* (Sudarsono et al., 2016), and laboratory settings to magnify the effects of the studied factors (Tarlao et al., 2022). All in all, audio-only laboratory settings are less representative of the studied environment and are thus less ecologically valid than in-situ conditions, highlighting the need to complement laboratory results with field evaluations to better inform the design of sound installations, as suggested in our research-creation collaboration framework.

In addition, all three studies highlighted the importance of complementing quantitative research with qualitative methods for evaluating soundscape interventions. In recent years, a prevailing approach to methodological triangulation has been to combine acoustic measurements with closed-ended soundscape evaluations (Botteldooren et al., 2023). However, our studies demonstrate the importance of triangulating closed- and open-ended data. In chapter 2, sound source listings allowed to reveal attentional masking at a subordinate level (e.g., birds for nature sounds), including for conditions where no effects of the installations were detected on closed-ended soundscape evaluation. In chapter 3 and 4, follow-up interviews provided crucial interpretative guidance, enabled the detection of high-level psychological phenomena such as *anamnesis* (Augoyard & Torgue, 2006), and were particularly important to derive precise design guidelines for the sound artists. Going further, we demonstrate the value of incorporating perspectives from outside the academic field—particularly from sound artists—to co-investigate unprecedented research questions and themes, thereby refining our understanding of the complex and holistic nature of soundscapes.

Beyond theoretical and methodological insights, a wealth of practical experiences underly this dissertation. The various exchanges with sound artists, along with the discoveries, challenges, discussions, and solutions encountered across the projects, have culminated in the development of a research-creation collaboration framework for evaluating and designing public space installations.

5.3. A collaboration framework to design and evaluate public space sound installations[9]

Based on the research-creation collaborations presented in chapters 2, 3 and 4, we propose a framework to inform the design and evaluation of public space sound installations in four stages, illustrated in Figure 5.1: 1) field recordings of pre-existing sound environments; 2) diagnosis of pre-existing sound environments and public space usage; 3) sound installation prototyping in laboratory settings; 4) evaluation after deployment. In comparison to the model proposed by Lacey (2016b), the framework is not prescriptive, nor it is a reflection on the theoretical or conceptual background of sound art in public space (on this matter, refer for instance to Di Croce, 2020; Livingston, 2016; Schütz, 2017; or Vogel, 2013). Instead, the framework consists of recommendations for the implementation of research-creation projects involving public space sound installations. It focuses on the methods (the *how*) and on the dynamics of the different stakeholders (the *who*) rather than on the esthetics (the *what*) involved in such project-grounded research (Findeli, 2018).

[9] This section is adapted from Fraisse, V., Wanderley, M. M., Misdariis, N., & Guastavino, C. (2024). Designing Sound for Public Spaces Through a Research-Creation Collaboration Framework. In Gray, C., Ciliotta, E., Hekkert, P., Forlano, L., Ciuccarelli, P., Lloyd, P. (Eds.), DRS2024, Boston, Massachusetts, USA.

This framework emerged from the different research-creation collaborations introduced in this dissertation, and is the result of a look back at these collaborations with sound artists which were central and critical to this research. For more details on the structure of these collaborations beyond the scientific outputs presented in this dissertation, we refer the reader to (Fraisse, Wanderley, et al., 2024; Guastavino et al., 2022b). By essence, the framework is modular and scalable: its application can take many forms and may be applied partially or with a different time frame depending on the timeline and nature of the artistic project. Furthermore, the order of the different stages can vary depending on the artistic project. It can be viewed as complementary to the design approach for soundscape planning and management proposed by Brown and Muhar (2004) in the context of sound installations. In this dissertation, stage 3 (Prototyping) is extensively discussed in chapters 3 and 4, and stage 4 (post-implementation *In situ* evaluations) in chapter 2. The first two stages (Field recordings and Diagnosis) were indirectly described in the thesis, but they significantly informed the experimental designs for each project. These stages did not only provide baseline material (e.g., recordings of the background sound environments) for soundscape prototyping; they helped inform the creative process across the three research-creation projects, for instance by providing an initial portrait of the acoustic and sonic profile of the site. Below is a short description of each stage followed by a discussion on the framework relevance.

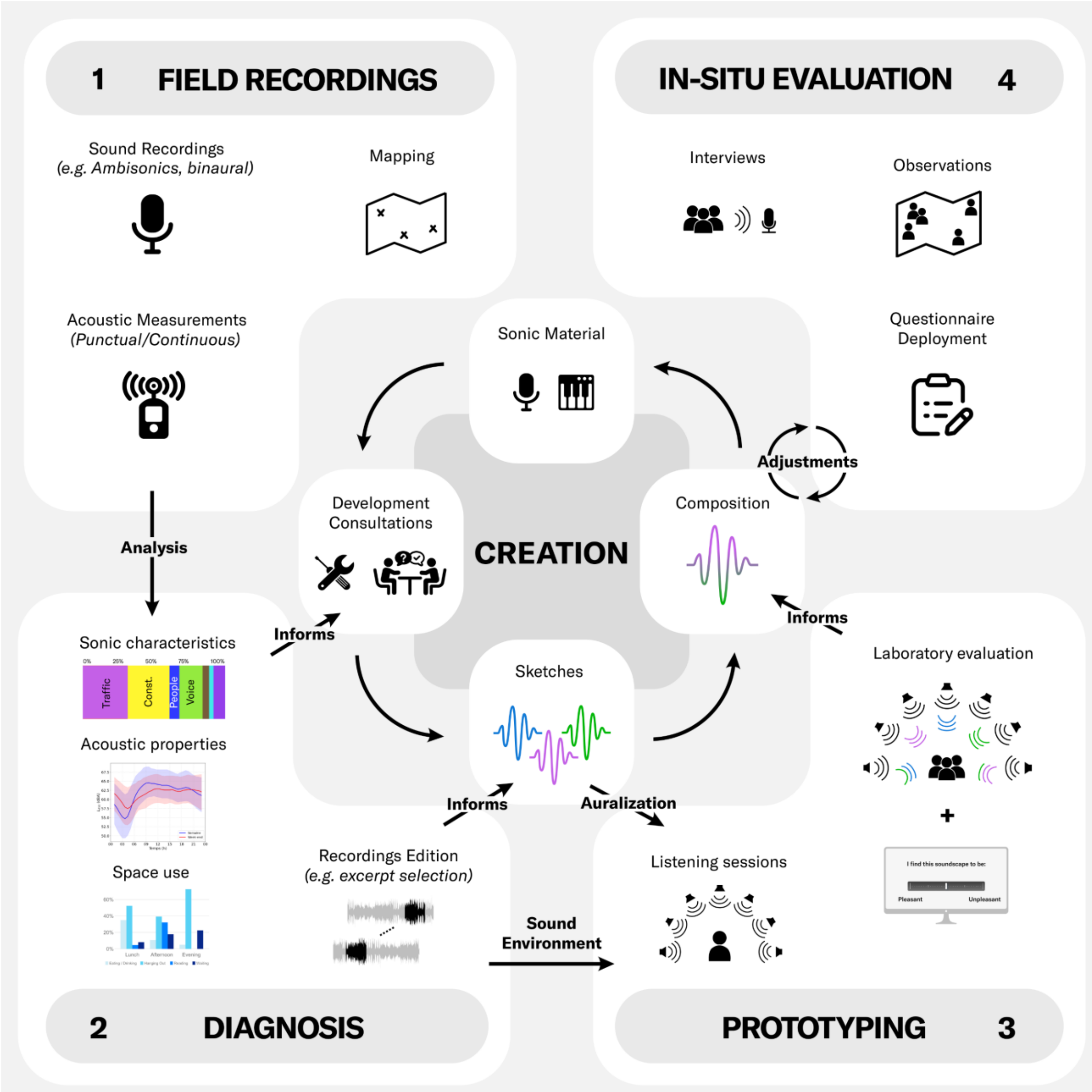


Figure 5.1. Illustration of the proposed research-creation collaboration framework to inform and evaluate public space sound installations. Four stages are proposed, the timing of which may vary across projects: (1) Field Recordings, (2) Diagnosis, (3) Prototyping, and (4) In-situ Evaluation. The framework is highly modular, scalable, and depends on site-specific parameters. Furthermore, the order of the different stages can vary in relation to the artistic project. It does not take all relevant factors into account but instead focuses on the interface between research and creation (illustration: Valérian Fraisse).

5.3.1. Stage 1 — Field recordings

This stage was preliminary to the studies reported in chapter 3 and 4. It aims to characterize the pre-existing sound environment through *ad hoc* recordings and continuous acoustic measurements. Recording positions should be considered in relation to the size of the space and the spatialization of the installation. For example, we sampled the forecourt of the Judicial Court in Paris (c. 7000 square meters) with a grid of 18 measurement points while only one position was retained in the *Parc des Madelinots* (c. 600 square meters). Choosing the right recording periods must also be discussed in relation to the artistic project. The most common approaches are to cover the patterns of activity commonly observed in the space (see Fraisse, Nicolas, et al., 2022) or to choose a single period representative of the site's average activity (see chapter 4). We recommend using Ambisonics recordings, with synchronous *ad hoc* sound level measurements to calibrate the sound environment reproduction and characterize the equivalent sound pressure level (Fraisse, Nicolas, et al., 2022). Continuous acoustic measurements can also be conducted depending on the available time and resources. Measurement point(s) should be far enough from the ground (e.g. between 1.2 and 1.5 m, see ISO 1996-2, 2017), vertical surfaces or trees, and should last at least a week to allow for the identification of profiles and trends. Additionally, stakeholders who possess prior knowledge of the space or have management responsibilities can provide valuable insights at this stage. For instance, they can provide relevant information about the public space (e.g., scale plan, measurements, eventually past surveys on the public space), and may even assist with taking measurements (see Guastavino et al., 2022).

5.3.2. Stage 2 — Initial diagnosis

Initial diagnosis depends on the data gathered during field recordings, and whether preliminary *in situ* observations have been possible. Field recording data can be analyzed for both sonic characteristics (e.g., the different sound events they contain) and acoustics (e.g., equivalent levels, statistical levels). For example, sound source annotations through listening sessions can be useful to characterize sonic variations through time, especially if recording sessions covered several periods with different activity levels. Automatic sound source identification can also be used (e.g., Kong et al., 2020). Acoustic indicators such as 10-minute or 30-minute equivalent levels (L_{Aeq}) can be computed from the *ad hoc* sound level measurements to characterize the overall sound level (for instance, we identified in chapter 2 a quiet side and a noisy side with punctual $L_{Aeq,10\ min}$). Other energy-based (e.g. third-octave levels, L_{DEN}, L_{A10}-L_{A90}) or signal-based indicators (e.g. loudness, sharpness, roughness) might also provide useful information (Can, 2019; Engel et al., 2021). Daily, weekly, or even seasonal dynamics can be characterized with continuous acoustic measurements, which can be helpful if the sound installation project is intended to evolve through time or to be implemented across months, seasons, or even years (a Python module has been proposed to help in the analysis of long-term sound level dynamics, see Fraisse, 2023). Continuous measurements can also help guide the *in situ* mastering of the installations. Finally, identifying the activities performed in the space and their dynamics through behavioral observations can allow the composer to tailor the installation's content to the use of space (see Guastavino et al., 2022).

5.3.3. Stage 3 — Prototyping

This stage was mainly investigated in chapters 3 and 4. It involves reproducing the site's sound environment using field recordings, and the auralization of the sound installation. Ambisonics can be decoded into various configurations of loudspeaker arrays or in binaural format. Hemispherical listening rooms are preferable (Moreau, 2006), but binaural recordings can also provide adequate reproductions of the background sound environment if more advanced laboratories are not available (J. Y. Hong et al., 2017). In our case studies, both First Order and Higher-Order (fourth order) Ambisonics provided satisfactory results in reproducing the background sound environment. Auralizing the content of the sound installation requires encoding the signal into an Ambisonics stream (preferably a Higher-Order stream for spatial accuracy) that can then be decoded together with the background sound environment. Auralization can consist of a simple panning as it was done in the Fleurs de-Macadam square (see Guastavino et al., 2022) or include acoustical modeling, using, for instance, soundscape simulation tools. Auralization can be also supplemented with visual stimuli from 2D videos to virtual reality (see, Li & Lau, 2020 for an overview). We developed a soundscape simulation tool for evaluating sound installations, not described in detail here for the sake of concision, but we refer the reader to (Fraisse, Schütz, et al., 2022) for a complete description of the development and evaluation of the tool. This tool and/or other simulation tools can be used for prototyping through listening sessions and/or laboratory studies. Listening sessions enable the creator to test spatial effects and master the composition in the presence of the sound environment. Although more resource-intensive, a laboratory study allows the composer to investigate the impacts of the sound installation on the overall soundscape, as evaluated by participants familiar with the space, to anticipate how it will be perceived on site. In the absence of site-specific constraints, a laboratory situation provides insights into the public opinion and enables design decisions before deployment. To be meaningful, the experiment must involve participants familiar with the studied site and to be adequately contextualized (Tarlao et al., 2022), and contrasting opinions may arise between and within different communities (e.g., local workers and residents). Incidentally, the process of creating sketches for a study encourages artists to materialize and delineate their composition strategies.

5.3.4. Stage 4 — *In situ* evaluations

This stage was investigated in chapter 2. Although it doesn't offer the same control as in the laboratory, the *in situ* evaluation of a sound installation provides the most ecologically valid feedback since it is done in real-life conditions. To systematically assess the impact of the sound installation, the evaluation must be performed with and without the intervention, controlling for non-acoustic factors (e.g., time of the day, day of the week, weather, person-related or situational factors, see ISO TS 12913-1, 2014). *In situ* evaluations can take many forms, the choice of which may be influenced by the type of public space. Questionnaires can be deployed with passers-by to measure the impact of the installation on soundscape evaluations. Space use can also be observed and annotated with and without the sound installation to measure its impact on variables such as social interactions (Bild, Steele, et al., 2016) or duration of stay (Aletta, Lepore, et al., 2016). Finally, *in situ* interviews or focus groups can be conducted with space users to explore more in-depth opinions (Di Croce & Guastavino, 2024; Steele, Bild, et al., 2019). Overall, applying different methods to assess the installation through what is called methodological triangulation is strongly recommended as it brings nuance and interpretative guidance for the design process (ISO TS 12913-2, 2018). In the context of the present framework, *in situ* evaluations can assess the extent to which the composition informed by the previous stages meets the artistic objectives and provide guidance on how to fine-tune the composition accordingly. In that sense, *in situ* evaluations complement previous laboratory studies as they can help confirm or refute previous theories and observations.

5.3.5. Significance of the framework

The framework emerged from the methodological research carried out across the research-creation collaborations presented in this dissertation. Its goal is to foster the development of soundscape assessment methods that are relevant to the artists, such as the questionnaire instrument and the soundscape simulator reported in chapters 2 and 3. Because the artistic projects presented in this thesis became part of—but were not limited to—the research projects, the research projects varied greatly depending on the artistic project. Thus, the proposed framework is highly modular and scalable: its application depends on the artistic intent of the installation, the timeline of the interventions, but also on the available technical resources and funding. For example, the large scale of the artistic project presented in chapter 3 allowed for extensive interactions between researchers and the artist, while the collaboration in chapter 2 was done in a relatively short time and with a different timeline due to the ephemeral nature of the interventions. The framework also leaves room for prototype iteration, especially during Prototyping (e.g., with consecutive laboratory studies, such as in the project presented in chapter 3) and *In situ* Evaluations (see Guastavino et al., 2022). Applying this framework also requires to properly document the interactions between the parties involved. It is not only the publishable data (such as the data reported in this dissertation) that is meaningful to the stakeholders but also the entire process involved and any other data (e.g., recordings, acoustic measurements, field notes, user evaluations, and even tacit knowledge). For instance, full transcripts of the semi-structured interviews conducted in chapters 3 and 4 were crucial to the composers to explore the detailed opinion of space users about the sound interventions.

The framework enables research *through* design—and more specifically, research through creation—whereby the artistic project itself is part of the research project, and the research itself is informed by this interaction (Findeli, 2018; Frankel & Racine, 2010). Compared to general practice in research through design (Stappers & Giaccardi, 2014), the research presented in this framework is not primarily conducted by the designer/artist. Instead, the researchers bring methods derived from soundscape research to inform the artists' work and generate methodological and theoretical knowledge. However, the research is not exclusively driven by scientific theories but also by collaborative opportunities: artists' design goals give direction to research and can even lead to specific research questions. For instance, a second laboratory study in the Paris project will explore the concept of acoustic niches (Augoyard & Torgue, 2006; Krause, 1993), which is part of the artistic statement of the sound installation. In that sense, artists' design prototypes can be considered "vehicles for theory building" (Stappers & Giaccardi, 2014). Regardless of its collaborative nature, this framework should also match situations where the fields of expertise represented by soundscape researchers and sound artists overlap, as is, for instance, often the case in ethnographic research on sound art (e.g., Lacey et al., 2019; Di Croce & Guastavino, 2024).

In a research-creation collaboration, the artistic project may influence the research objectives, but the research goals should not be confined to the artistic aims alone, nor should the artistic goals be limited to the research aims. There is an essential boundary between the research question and the artistic question, such that compromise is necessary and inevitable (Findeli, 2018). In the case of public space sound installations, this poses several challenges for both artists and researchers. Although the collaboration can help artists reflect on their design activities and explore new design spaces (Stappers & Giaccardi, 2014), they have to structure their work in an unusual way, and even deconstruct their work to generate clearly delineated compositions for prototyping or *in situ* evaluation. In addition, they expose their work to the evaluation and criticism of space users, whose awareness of the work is controlled (at least in a laboratory setting) and who do not evaluate the interventions as an artwork but rather as their own sound environment (Tittel, 2009). This can be critical in laboratory settings, where stimuli are isolated from other sensory modalities and cognitive processes (e.g., expectations, associations) are different, thereby magnifying the perception of soundscape interventions (Tarlao et al., 2022). As for researchers, they have to leave room for the artist's creativity and might have to compromise on the level of control over the stimuli (compared to a typical soundscape study). They are also constrained by the timeline of the artistic projects. For instance, in chapter 4, the installation was already deployed during the laboratory study, potentially affecting participants' opinion on the installation when evaluating it. In addition, we recognize that applying this collaboration framework requires a great deal of time and resources, which might limit its accessibility to sound artists. Finally, the framework was elaborated based on case studies involving only loudspeakers. Other forms of sound generation, such as elemental or resonant installations (see Lacey, 2016a), may raise technical and methodological issues that were not considered here (e.g., how to generate sketches of an eolian harp and could physical modelling be used to simulate it in a virtual environment? How to generalize results obtained with recorded or modelled stimuli when *in situ* sound-making is everchanging?). Future research is therefore needed to extend this framework to other types of installation.

Beyond these limitations, these interactions are mutually beneficial for both artists and researchers by opening the door for knowledge sharing and production. As experienced listeners, sound artists have a rare expertise in sound and often propose novel solutions to soundscape design (Cobussen, 2023). They can provide researchers with new insights into the nature and purpose of a soundscape intervention, questioning the addition of specific sound sources—such as birdsong and water stream sounds—as a blanket solution. Although less generalizable, the results of these studies take on a tangible form as they contribute to the creative works. Conversely, such collaborations provide artists with a systematic evaluation of the existing soundscape and the impact of their work. This feedback constitutes not only invaluable data to the artist in their creative process, but also a way to promote their work to public stakeholders.

We reflected in the previous sections on the theoretical and methodological outcomes of the work presented in this dissertation (research *through* design), but the collaborations also resulted in site-specific design guidelines for each of the artistic projects throughout the stages of the framework (research *for* design). The Fleurs-de-Macadam, presented in chapter 2, took place over 2 years. In the first year, the research team formulated simple guidelines for the creation, namely to reinforce the purpose of the temporary design (relaxation or culture) through sound. The sound artists were entirely responsible for the creative process. In the second year, the research team provided the sound artists with an analysis of space use and sound levels—stages 1 and 2 of the framework—leading to recommendations regarding the temporal and spatial evaluation of the temporary installations in relation to compositional strategies derived from the literature (e.g. oppositional vs. backgrounded, referential vs. abstract). Listening sessions in laboratory settings—stage 3 of the framework—also informed their composition, specifically in terms of optimal speaker positioning to create spatial effects when walking through the public space (more detail in Guastavino et al., 2022). For the *Niches Acoustiques* sound installation, design recommendations regarding the spectrotemporal evolution of the future installation were derived from extensive field recordings and diagnosis sessions—stages 1 and 2, reported in Fraisse, Nicolas, et al., (2022)—in addition to results of the laboratory study reported in chapter 3. Regarding the collaboration around *Les Madelinéennes* installation, laboratory results presented in chapter 4 led to specific guidelines regarding the nature and dominance of sound sources used in the compositions. Ultimately, the different research outcomes validated by community response allowed to back up the potential benefits of the different artistic projects among urban stakeholders. Similarly, the different publications and conferences provided means for the sound artists to further document and legitimate their work in the eyes of urban stakeholders and city officials.

5.4. Limitations & future directions

This section discusses general limitations of the work described in this dissertation. Limitations specific to the collaboration framework are described above, while specific study limitations are detailed in the corresponding chapters.

The primary goal of this research was to investigate the soundscape effects of public space sound installations and to develop methods in order to inform their design based on these evaluations. As mentioned previously, this requires providing creative space for the sound artists and less control over the stimuli compared to a typical soundscape study. This only allowed for the formulation of high-level hypotheses (e.g., abstract sounds are more oppositional than referential sounds, natural sounds are more restorative) and made it difficult to provide clearly delineated factorial designs, whether in situ (e.g., Chen & Kang, 2023; Zhao et al., 2020) or in laboratory settings (e.g., Han et al., 2023; Nilsson et al., 2010). It was difficult to investigate finer grain theoretical issues, such as linking soundscape effects to the acoustic, psychoacoustic, or timbral features of the added sounds (see for instance Bouvier, 2024; Hong, Ong, et al., 2020; Rosi, 2022). For instance, we could not identify any relationship between the composition sketches' evaluations in laboratory settings (chapters 3 and 4) and their acoustic features such as their spectral centroid, roughness, sharpness, fluctuation strength, or zero-crossing rate. These issues will be explored in future works through a finer-grain control of the experimental stimuli. For instance, we seek to assess how the spectrotemporal morphology of introduced sounds in comparison with the background sound environment affects soundscapes in a second laboratory study on *Niches Acoustiques*.

Conversely, we encountered issues of statistical power in each of the studies. In chapter 2, the difficulty to control extraneous variables sometimes led to potentially imbalanced samples regarding demographic variables. In chapters 3 and 4, the prerequisite for ecological validity[10] and representativity required recruiting participants familiar to the studied sites and constrained sample sizes. In each of the three studies, we were

[10] The notion of ecological validity refers to the need to study perception under ecological conditions, i.e. to consider contextual cues so that the participants react as if they were in a natural situation (see Guastavino et al., 2005; Tarlao et al., 2022).

sometimes unable to detect statistically significant effects of the sound installations despite low to medium effect sizes. Low sample sizes have also prevented the investigation of the relationship between various personal and contextual factors and the perceived effects of the sound installations. For instance, we could not compare the effects of the added sounds across local workers and residents in chapter 3, although preliminary results suggest that residents might be more likely to enjoy the sound installation. Further research is required in this direction, by recruiting more participants and eventually aggregating results from different studies through statistical modelling (e.g., Tarlao et al., 2021).

Another limitation is sampling bias. Participants approached *in situ* already chose to use the public space and were likely to have high evaluations of the environment, while those recruited for the laboratory experiments had the time and resources to commute to the laboratory and had at least some interest in their sound environment (either positive or negative). For instance in chapter 4, we could not investigate the impact of the sound installation among Madelinean people as the advanced average age of members of this community might have made it difficult for them to come to the laboratory. More inclusive research methods should be investigated in future studies (e.g. focus groups or listening sessions directly in the Madelinean community center in the case of *Les Madelinéennes* installation). Some key features of sound installation art were also not investigated in this dissertation. First, we could not evaluate the influence of prolonged exposure to the sound installations (in terms of seasons, or years). Long-term evaluations of public space sound installations are challenging, because they require the mobilization of research efforts over several seasons or years, involve long-term psychological and cognitive effects such as habituation, but also because installations can deteriorate over time, and public spaces are dynamic systems that are subject to change[11]. Thus, it would be interesting to establish a method relevant for the long-term field evaluation of public space sound installations. The permanent installations *Les Madelinéennes* and *Niches Acoustiques* investigated in chapters 3 and 4 are of course ideal candidates for setting up such a research project in the future. Other key compositional features which were not

[11] See for instance Eppley's (2017) discussion on the issues raised during the restoration of Max Neuhaus' iconic *Times square* installation.

investigated include the spatial articulation of the sound installations in regards with space users' motion, as well as the influence of visuals and other sensory modalities (e.g., thermal comfort, embodied cognition, smells) on their reception. Investigating the influence of spatial relationship with an installation might be challenging as it requires complex experimental setups (e.g., see Meng et al., 2018), but visuals could be investigated in the near future (e.g., see Hong, Lam, et al., 2020; Oberman et al., 2020).

Another important matter is the way we accommodated participants' subjectivity within our research. First, and this is a classical concern in soundscape studies (see for instance Hellstrom et al., 2014), participants were explicitly asked to focus on their sound environment in each of our studies. This instruction puts them in a high-level of listening attention or "*listening-in-search*" in Truax's words (1984), although we usually listen passively to our day-to-day sound environments. This is likely to influence participants' reception of the sound installations, on site and especially in laboratory settings which tend to magnify the effects of studied factors (see section 5.2). Further, we mostly addressed the ecological validity in our studies in terms of representativity of the studied population (notwithstanding a potential sampling bias) and the representativity of the stimuli, but the experimental task and procedures undertook by the participants during the in situ and laboratory studies (evaluating soundscape scales, being interviewed) were not representative of the studied cognitive process in real-life conditions, limiting the ecological validity of this research (see Tarlao et al., 2022). A more intricate issue regards participants' awareness of the artistic projects. We did not disclose the purpose of the experiment until the end of each study, mainly for two reasons. First, to minimize bias relative to participants' opinions on sound installation art—which could be either indifferent, hostile or sympathetic to the idea of adding sounds to public spaces. Awareness that the results will be communicated to the sound installation's creator might also incentivize participants to politely express their approval (Robson et al., 2023). Second, because most space users will not be aware of the artistic intentions of a given sound installation, even if it draws their attention. For instance in the case of *Les Madelinéennes* sound installation, only a few people were aware of the presence of the sound installation at the time of the study (a few months after its initial deployment), and only one participant was actually aware of the artistic project. Nonetheless, this choice is debatable and was the subject of many discussions with the artists. Disclaiming our research intentions through a more reflexive approach might also bring interesting perspectives (Gough & Madill, 2012), and it would be worthwhile investigating how the awareness of an intervention affects its reception. After all, some participants reported during the follow-up interviews in chapters 3 and 4 that their evaluations would have been different if they were informed of the goal of the experiment beforehand.

Otherwise, an important perspective would be to better involve participants in the composition processes. In the studies presented chapters 2 to 4, participants' feedback was only indirectly informing the installations' design. Future works could imply participatory approaches where the local community is actively involved in the creation of a sound installation. For instance, one could ask residents or local workers to participate to an installation's design through workshops (e.g., Di Croce & Guastavino, 2024), or co-design activities (e.g., D'Elia et al., 2024; Prado & Mazzarotto, 2024). Similarly, the three studies were conducted in favorable socio-economic contexts: the three public spaces are located in Global North cities, in urban areas with recognized urban planning qualities (walkability, amenities, access to green spaces, etc.). It is worth investigating whether the proposed framework and the theoretical findings are transferrable to other contexts and cultures (see for instance Duarte-García & Wilde, 2021; Ouzounian, 2021).

Immediate next steps involve evaluating both *Les Madelinéennes* and *Niches Acoustiques* once deployed. Hence, the collaboration framework proposed in section 5.3 was only partially applied: in chapter 2, prototyping did not involve a laboratory study, while in chapter 3 and 4, we did not (yet) investigate the *in situ* impact of the sound installations. We also have not investigated how soundscape's familiarity might be impacted by a sound installation *in situ* as the dimension was proposed later on, and we need to address whether the potential for sound installations to rupture or diversify soundscapes persists in the field. *In situ* evaluations will be likely challenging in the context of the public spaces investigated in chapter 3 and 4, as they are mostly transit spaces. However, they would complement the laboratory evaluations and most likely bring new perspectives to the table.

CHAPTER 6. CONCLUSION

The objectives of this dissertation were to investigate the potential effects of sound installation art on the auditory experience of public space users and to develop methodological tools for informing the design of public space sound installations based on their reception, in relation to other contextual factors. Our research questions were:

1. *How do public space users evaluate everyday urban soundscapes in the presence of sound art? Specifically, how do public space users' soundscape evaluations vary for different sound art composition strategies?*
2. *How can soundscape evaluations inform the design of public space sound installations?*

Because of the idiosyncratic nature of site-specific sound art, both questions were addressed across three different research-creation projects, involving different artists, public spaces, and timelines. The research conducted in each of these collaborations provided complementary theoretical, methodological and practical findings.

First, we contributed to theoretical knowledge on the effects of sound art on public space soundscape. The three studies provided complementary insights and revealed commonalities in the way sound installations affect public soundscapes. We have shown that sound installations have a strong potential to affect soundscape's familiarity and variety (cf. chapters 3 and 4), tend to improve *in situ* soundscape assessments (cf. chapter 2), and to distract from other, non-dominant sound sources (cf. chapters 2 and 4). But we also identified specific effects in relation to composition strategies. The studies presented in chapters 2 and 3 indicated that the abstract/referential characteristics of the introduced sounds affect their propensity to be oppositional: more abstract sounds tend to be more noticeable as they have broader effects on soundscape evaluations and lead to stronger attentional masking. However, we have also seen in chapter 4 that the oppositional nature of the added sounds is related to their congruency. Finally, we have highlighted the evocative power of unusual sounds, as illustrated by the diversity of individual associations reported in chapter 3, and especially in chapter 4.

The contributions of this dissertation remain chiefly methodological, as we sought to investigate appropriate methods to evaluate urban soundscapes in the presence of sound art in order to inform the design of sound installations. First, we demonstrated the value of combining scales related to overall soundscape evaluation and restorativeness with sound source listings, and highlighted the importance of controlling spatial and temporal factor for the *in situ* evaluation of soundscape interventions (cf. chapter 2). In laboratory settings, we developed a field recordings protocol and validated a soundscape simulation tool for evaluating sound installations (cf. chapters 3 and 4). We also showed the effectiveness of using a questionnaire instrument based on three components: pleasantness, variety, and familiarity, and the benefits of triangulating soundscape ratings with follow-up interviews (cf. chapters 3 and 4). Otherwise, we demonstrated the usefulness of a protocol for recalling significant moments during follow-up interviews to characterize the evocations elicited by composition sketches and to offer detailed guidance for the composer (cf. chapter 4). We finally proposed a research-creation collaboration framework for designing and evaluating public space sound installations (cf. chapter 5, section 5.3). This framework, which is a direct outgrowth of the methodological research discussed in the thesis, is divided into four stages: field recordings, diagnosis, prototyping, and *in situ* evaluation. It includes modular guidelines and recommendations for designing and evaluating public space sound installation using soundscape evaluations.

Finally, this research has practical implications. The collaboration framework is a practical contribution in itself, integrating various tools and methods to help sound artists interested in the soundscape effects of their work (cf. chapter 5, section 5.3). These include a module for analyzing sound levels, a soundscape simulation tool and the associated evaluation protocol, and a questionnaire instrument. The three studies also resulted in design guidelines at different stages of the collaborations (cf. chapters 2,3, and 4). While this research highlighted the challenges of designing sounds for urban public spaces, it also promoted the work of sound artists among urban stakeholders by demonstrating that their installations could benefit urban soundscapes. In turn, sound artists brought new ideas and tailored alternatives for (re)designing public spaces, drawing on their unique expertise and practice. This underscores the importance of integrating stakeholders—here, sound artists—directly into the research process to bridge the gap between academia and practice in soundscape studies.

This research naturally comes with several limitations (cf. chapter 5, section 5.4). First, only high-level hypotheses were formulated, and we could not link soundscape effects of the sound installations to their acoustic, psychoacoustic, or timbral features. Conversely, we lacked statistical power for each of our studies, which prevented the investigation of the relationship between personal and contextual factors and the perceived effects of the sound installations. We also did not investigate some key features of sound installation art, including their long-term impact, their spatial articulation in relation to visitors' motion, or the influence of visuals and other sensory modalities. The way we accommodated participants' subjectivity also affected their evaluations. For instance, they were asked to focus on their sound environments, while we did not disclose the purpose of the experiments until the end of each study. Otherwise, participants had limited involvement in the composition processes, especially when compared to participatory approaches. Finally, the studies are limited to specific socio-cultural contexts (namely, in well-planned neighborhoods from Global North cities).

Overall, this research opens up new avenues to investigate the soundscape impacts of public space sound installations. From the future directions mentioned in chapter 5, there are two lines of research that we would prioritize. First, it is essential to continue investigating the impact of soundscape interventions, including the complex relationship between added sounds and their impact on urban soundscapes. A next step could be to examine the role of both the semantics and the spectrotemporal morphology of introduced sounds in relation to existing soundscapes. Second, to fully operationalize the collaboration framework, especially by exploring how *in situ* soundscape evaluations can complement the design guidelines obtained from previous laboratory experiments. This should refine our understanding of how sound installations and, more broadly, soundscape interventions can impact urban soundscapes, in an attempt to make our cities sound better.

REFERENCES

About the ElectroAcoustic Resource Site project. (2023). ElectroAcoustic Resource Site. http://ears.huma-num.fr/index.html

Adhitya, S. (2017). Implementation. In *Musical Cities* (DGO-Digital original, pp. 90–103). UCL Press. https://doi.org/10.2307/j.ctv550cz9.17

Adhitya, S., & Scott, D. (2018). The London Soundmap: Integrating sonic interaction design in the urban realm. *Audio Mostly on Sound in Immersion and Emotion*, 1–7. https://doi.org/10.1145/3243274.3243302

Aletta, F., Kang, J., & Axelsson, Ö. (2016). Soundscape descriptors and a conceptual framework for developing predictive soundscape models. *Landscape and Urban Planning*, *149*, 65–74. https://doi.org/10.1016/j.landurbplan.2016.02.001

Aletta, F., Lepore, F., Kostara-Konstantinou, E., Kang, J., & Astolfi, A. (2016). An Experimental Study on the Influence of Soundscapes on People's Behaviour in an Open Public Space. *Applied Sciences*, *6*(10), 276. https://doi.org/10.3390/app6100276

Aletta, F., & Xiao, J. (2018). What are the Current Priorities and Challenges for (Urban) Soundscape Research? *Challenges*, *9*(1), Article 1. https://doi.org/10.3390/challe9010016

Allsop, D. B., Chelladurai, J. M., Kimball, E. R., Marks, L. D., & Hendricks, J. J. (2022). Qualitative Methods with Nvivo Software: A Practical Guide for Analyzing Qualitative Data. *Psych*, *4*(2), Article 2. https://doi.org/10.3390/psych4020013

Alvarsson, J. J., Wiens, S., & Nilsson, M. E. (2010). Stress Recovery during Exposure to Nature Sound and Environmental Noise. *International Journal of Environmental Research and Public Health*, *7*(3), 1036–1046. https://doi.org/10.3390/ijerph7031036

Amadeus | PMX 4. (2023). https://amadeuslab.com/en/pmx_4.php

Amiri, M., & Jarollahi, F. (2020). An overview on informational masking. *Auditory and Vestibular Research*, *29*(3), 128–139. https://doi.org/10.18502/avr.v29i3.3845

Anderson, S. (2008). Microsound in public space: Compositional methods to enhance site-specific sound. *Organised Sound*, *13*(1), 51–60. Scopus. https://doi.org/10.1017/S1355771808000071

Arroyo, E., Bonanni, L., & Valkanova, N. (2012). Embedded interaction in a water fountain for motivating behavior change in public space. *Conference on Human Factors in Computing Systems - Proceedings*, 685–688. Scopus. https://doi.org/10.1145/2207676.2207773

Augoyard, J.-F. (2001). L'entretien sur l'écoute réactivée. In M. Grosjean & J.-P. Thibaud (Eds.), *L'espace urbain en méthodes* (pp. 127–153). Parenthèses.

Augoyard, J.-F., & Torgue, H. (2006). *Sonic Experience: A Guide to Everyday Sounds*. McGill-Queen's Press - MQUP.

Axelsson, Ö., Nilsson, M. E., & Berglund, B. (2010). A principal components model of soundscape perception. *The Journal of the Acoustical Society of America*, *128*(5), 2836–2846. https://doi.org/10.1121/1.3493436

Axelsson, Ö., Nilsson, M. E., & Berglund, B. (2012). The Swedish soundscape-quality protocol. *The Journal of the Acoustical Society of America*, *131*(4), 3476. https://doi.org/10.1121/1.4709112

Axelsson, Ö., Nilsson, M. E., Hellström, B., & Lundén, P. (2014). A field experiment on the impact of sounds from a jet-and-basin fountain on soundscape quality in an urban park. *Landscape and Urban Planning*, *123*, 49–60. https://doi.org/10.1016/j.landurbplan.2013.12.005

Bandt, R. (2006). Sound installation: Blurring the boundaries of the eye, the ear, space and time. *Contemporary Music Review*, *25*(4), 353–365. Scopus. https://doi.org/10.1080/07494460600761021

Baxter, K., Courage, C., & Caine, K. (2015). Chapter 7—During Your User Research Activity. In K. Baxter, C. Courage, & K. Caine (Eds.), *Understanding your Users (Second Edition)* (pp. 158–189). Morgan Kaufmann. https://doi.org/10.1016/B978-0-12-800232-2.00007-9

Bégout, B. (2020). *Le Concept d'Ambiance* (L'Ordre Philosophique). Le Seuil.

Bild, E., Coler, M., Pfeffer, K., & Bertolini, L. (2016). Considering Sound in Planning and Designing Public Spaces: A Review of Theory and Applications and a Proposed Framework for Integrating Research and Practice. *Journal of Planning Literature*, *31*(4), 419–434. https://doi.org/10.1177/0885412216662001

Bild, E., Steele, D., Tarlao, C., Guastavino, C., & Coler, M. (2016). Sharing music in public spaces: Social insights from the Musikiosk project (Montreal, CA). *Proceedings of Internoise*, 6834–6843. Scopus.

Bird Checklists of the World. (2024). https://avibase.bsc-eoc.org/checklist.jsp?region=caqc16&list=aou&lang=EN

Botteldooren, D., De Coensel, B., Aletta, F., & Kang, J. (2023). Triangulation as a Tool in Soundscape Research. In B. Schulte-Fortkamp, A. Fiebig, J. A. Sisneros, A. N. Popper, & R. R. Fay (Eds.), *Soundscapes: Humans and Their Acoustic Environment* (pp. 215–241). Springer International Publishing. https://doi.org/10.1007/978-3-031-22779-0_8

Bouvier, B. (2024). *Saillance auditive: De la caractérisation psychoacoustique à la perception de l'environnement sonore* [PhD Thesis, Sorbonne Université]. https://theses.hal.science/tel-04562041

Brown, L. A. (2010). Soundscapes and environmental noise management. *Noise Control Engineering Journal*, *58*(5), 493–500. https://doi.org/10.3397/1.3484178

Brown, L. A., Gjestland, T. T., & Dubois, D. (2016). Acoustic Environments and Soundscapes. In *Soundscape and the Built Environment*. CRC Press.

Brown, L. A., & Muhar, A. (2004). An approach to the acoustic design of outdoor space. *Journal of Environmental Planning and Management*, *47*(6), 827–842. https://doi.org/10.1080/0964056042000284857

Brüel & Kjær. (2023). https://www.bksv.com/en/instruments/handheld/sound-level-meters/2250-series

Bryan-Kinns, N. (2014). Mutual Engagement in Digitally Mediated Public Art. In L. Candy & S. Ferguson (Eds.), *Interactive Experience in the Digital Age: Evaluating New Art Practice* (pp. 123–138). Springer International Publishing. https://doi.org/10.1007/978-3-319-04510-8_9

Cadena, L. F. H., Soares, A. C. L., Pavón, I., & Coelho, L. B. (2017). Assessing soundscape: Comparison between in situ and laboratory methodologies. *Noise Mapping*, *4*(1), 57–66. https://doi.org/10.1515/noise-2017-0004

Cage, J. (1961). *Silence: Lectures and Writings*. Wesleyan University Press.

Calarco, F. M. A., & Galbrun, L. (2024). Sound mapping design of water features used over road traffic noise for improving the soundscape. *Applied Acoustics*, *219*, 109947. https://doi.org/10.1016/j.apacoust.2024.109947

Can, A. (2019). *Dynamic approaches for the characterization and mitigation of urban sound environments* [Mémoire d'Habilitation à Diriger des Recherches]. Université Gustave Eiffel.

Canonne, C., & Fryberger, A. (2020). But If It's Not Music, What Is It? Defining Interstitial Artistic Practices. *Circuit : Musiques Contemporaines*, *30*(1), 41–52. https://doi.org/10.7202/1069082ar

Cerwén, G. (2016). Urban soundscapes: A quasi-experiment in landscape architecture. *Landscape Research*, *41*(5), 481–494. https://doi.org/10.1080/01426397.2015.1117062

Cerwén, G. (2021). *Sound art Archives*. Soundscape Design. https://soundscapedesign.info/category/sound-art/

Cerwén, G., Kreutzfeldt, J., & Wingren, C. (2017). Soundscape actions: A tool for noise treatment based on three workshops in landscape architecture. *Frontiers of Architectural Research*, *6*(4), 504–518. https://doi.org/10.1016/j.foar.2017.10.002

Chau, C. K., Leung, T. M., Chung, W. K., & Tang, S. K. (2023). Effect of perceived dominance and pleasantness on the total noise annoyance responses evoked by augmenting road traffic noise with birdsong/stream sound. *Applied Acoustics*, *213*, 109650. https://doi.org/10.1016/j.apacoust.2023.109650

Chen, X., & Kang, J. (2023). *Natural sounds can encourage social interactions in urban parks*. https://doi.org/10.1016/j.landurbplan.2023.104870

CIRMMT Facilities. (2024). CIRMMT. https://www.cirmmt.org/en/facilities

Citton, Y. (2017). *The Ecology of Attention* (1. édition). Polity.

Cobussen, M. (2023, September 19). The Role of Sound Art in Soundscape Design. *Forum Acusticum*.

Davies, W., Adams, M., Bruce, N., Cain, R., Carlyle, A., Cusack, P., Hume, K., Jennings, P., & Plack, C. (2007, September 2). The positive soundscape project. *International Congress on Acoustics*. International Congress on Acoustics, Madrid, Spain.

Davies, W., Bruce, N., & Murphy, J. (2014). Soundscape Reproduction and Synthesis. *Acta Acustica United with Acustica*, *100*(2), 285–292. https://doi.org/10.3813/AAA.918708

De Coensel, B., Vanwetswinkel, S., & Botteldooren, D. (2011). Effects of natural sounds on the perception of road traffic noise. *The Journal of the Acoustical Society of America*, *129*(4), EL148–EL153. https://doi.org/10.1121/1.3567073

De Pessemier, T., Van Renterghem, T., Vanhecke, K., All, A., Filipan, K., Sun, K., De Coensel, B., De Marez, L., Martens, L., Botteldooren, D., & Joseph, W. (2022). Enhancing the park experience by giving visitors control over the park's soundscape. *Journal of Ambient Intelligence and Smart Environments*, *14*(2), 99–118. https://doi.org/10.3233/AIS-220621

De Winne, J., Filipan, K., Moens, B., Devos, P., Leman, M., Botteldooren, D., & De Coensel, B. (2020). The Soundscape Hackathon as a Methodology to Accelerate Co-Creation of the Urban Public Space. *Applied Sciences*, *10*(6), Article 6. https://doi.org/10.3390/app10061932

DeJonckheere, M., & Vaughn, L. M. (2019). Semistructured interviewing in primary care research: A balance of relationship and rigour. *Family Medicine and Community Health*, *7*(2), e000057. https://doi.org/10.1136/fmch-2018-000057

D'Elia, L., Imbesi, L., & Muscolo, S. (2024). MakIN'Rome living lab. A case study of design-driven approach for the development of urban community-based projects. *DRS Biennial Conference Series*. https://dl.designresearchsociety.org/drs-conference-papers/drs2024/researchpapers/376

Deng, L., Rising, H. H., Gu, C., & Bimal, A. (2024). The Mitigating Effects of Water Sound Attributes on Stress Responses to Traffic Noise. *Environment and Behavior*, 00139165241245829. https://doi.org/10.1177/00139165241245829

Di Croce, N. (2020). Beyond the Rhetoric of Social Innovation. Relational Sound Art as a Driver for Urban Regeneration. In G. Borelli & M. Busacca (Eds.), *Society and the City: The Dark Sides of Social Innovation* (pp. 95–110). Mimesis.

Di Croce, N., & Guastavino, C. (2024). Towards a sensory approach in tactical urbanism: Participatory sound-based interventions in the neoliberal city. *Manuscript Submitted for Publication*.

Duarte-García, M. A., & Wilde, E. (2021). Sound installation art and the intervention of urban public space in Latin America. *SoundEffects - An Interdisciplinary Journal of Sound and Sound Experience*, *10*(1), Article 1. https://doi.org/10.7146/se.v10i1.124201

Dubois, D., Guastavino, C., & Raimbault, M. (2006). A cognitive approach to urban soundscapes: Using verbal data to access everyday life auditory categories. *Acta Acustica United with Acustica*, *92*, 865–874.

Easteal, M., Bannister, S., Kang, J., & Aletta, F. (2014). Urban Sound Planning in Brighton and Hove. *Proceedings of the FORUM ACUSTICUM*. http://dx.doi.org/10.13140/2.1.2772.0964

Engel, M. S., Fiebig, A., Pfaffenbach, C., & Fels, J. (2021). A Review of the Use of Psychoacoustic Indicators on Soundscape Studies. *Current Pollution Reports*. https://doi.org/10.1007/s40726-021-00197-1

Eno, B. (1978). *Music for Airports liner notes*. http://music.hyperreal.org/artists/brian_eno/MFA-txt.html

Eppley, C. (2017). Times Square: Strategies and Contingencies of Preserving Sonic Art. *Leonardo Music Journal*, *27*, 21–26. Scopus. https://doi.org/10.1162/LMJ_a_01003

Erbe, C., Dent, M. L., Gannon, W. L., McCauley, R. D., Römer, H., Southall, B. L., Stansbury, A. L., Stoeger, A. S., & Thomas, J. A. (2022). The Effects of Noise on Animals. In C. Erbe & J. A. Thomas (Eds.), *Exploring Animal Behavior Through Sound: Volume 1: Methods* (pp. 459–506). Springer International Publishing. https://doi.org/10.1007/978-3-030-97540-1_13

European Comission. (2024, August 2). *Environmental Noise Directive*. https://environment.ec.europa.eu/topics/noise/environmental-noise-directive_en

Farina, A. (2013). Soundscape Ecology: Principles, Patterns, Methods and Applications. In *Soundscape Ecology: Principles, Patterns, Methods and Applications* (p. 315). Springer. https://doi.org/10.1007/978-94-007-7374-5

Fiebig, A., & Schulte-Fortkamp, B. (2023). How to Put Soundscape into Practice. In B. Schulte-Fortkamp, A. Fiebig, J. A. Sisneros, A. N. Popper, & R. R. Fay (Eds.), *Soundscapes: Humans and Their Acoustic Environment* (pp. 313–330). Springer International Publishing. https://doi.org/10.1007/978-3-031-22779-0_11

Filipan, K., De Coensel, B., Aumond, P., Can, A., Lavandier, C., & Botteldooren, D. (2019). Auditory sensory saliency as a better predictor of change than sound amplitude in pleasantness assessment of reproduced urban soundscapes. *Building and Environment*, *148*, 730–741. Scopus. https://doi.org/10.1016/j.buildenv.2018.10.054

Findeli, A. (2018). Recherche-création et recherche-projet: Même combat ? In *Pour une éthique partagée de la recherche-création en milieu universitaire* (pp. 41–60). Les Presses de l'Université Laval.

Fraisse, V. (2019). *Improving Urban Soundscapes through Sound Installations: An in situ Study in a Montreal Pocket Park*. [Master's Thesis]. IRCAM.

Fraisse, V. (2023). noisemonitor: A Python Package For Sound Level Monitor Analysis. *Acoustics Week in Canada*.

Fraisse, V., Giannini, N., Guastavino, C., & Boutard, G. (2022). Experiencing Sound Installations: A conceptual framework. *Organised Sound*, *27*(2), 227–242. https://doi.org/10.1017/S135577182200036X

Fraisse, V., Nicolas, E., Schütz, N., Ribeiro, C., & Misdariis, N. (2022). Évaluer l'impact d'installations sonores sur la perception du paysage sonore urbain: Cas d'étude d'une place publique parisienne. *16e Congrès Français d'Acoustique*.

Fraisse, V., Schütz, N., Wanderley, M., Guastavino, C., & Misdariis, N. (2022, August 23). Informing sound art design in public space through soundscape simulation. *Proceedings of Internoise*.

Fraisse, V., Schütz, N., Wanderley, M. M., Guastavino, C., & Misdariis, N. (2024). Using Soundscape Simulation to Evaluate Compositions for a Public Space Sound Installation. *Journal of the Acoustical Society of America*, *156*(2), 1183–1201. https://doi.org/10.1121/10.0028184

Fraisse, V., Steele, D., d'Ambrosio, S., & Guastavino, C. (2020). Shaping urban soundscapes through sound art: A case study in a public square exposed to construction noise. *International Workshop on Haptic and Audio Interaction Design*.

Fraisse, V., Tarlao, C., & Guastavino, C. (2024). Shaping City Soundscapes: In-Situ Evaluation of Four Sound Installations in an Urban Public Space. *Landscape and Urban Planning*, *251*, 105173. https://doi.org/10.1016/j.landurbplan.2024.105173

Fraisse, V., Wanderley, M. M., & Guastavino, C. (2021). Comprehensive Framework for Describing Interactive Sound Installations: Highlighting Trends through a Systematic

Review. *Multimodal Technologies and Interaction*, *5*(4), Article 4. https://doi.org/10.3390/mti5040019

Fraisse, V., Wanderley, M. M., Misdariis, N., & Guastavino, C. (2024). Designing Sound for Public Spaces Through a Research-Creation Collaboration Framework. *Design Research Society Conference*. https://doi.org/10.21606/drs.2024.1083

Franěk, M., Rezny, L., Šefara, D., & Cabal, J. (2019). Effect of birdsongs and traffic noise on pedestrian walking speed during different seasons. *PeerJ*, *7*. https://doi.org/10.7717/peerj.7711

Franinovic, K., & Visell, Y. (2007). New musical interfaces in context: Sonic interaction design in the urban setting. *Proceedings of the New Interfaces for Musical Expression*, 191–196. https://doi.org/10.1145/1279740.1279776

Frankel, L., & Racine, M. (2010). The Complex Field of Research: For Design, through Design, and about Design. *DRS Biennial Conference Series*. https://dl.designresearchsociety.org/drs-conference-papers/drs2010/researchpapers/43

Friedrich, S., Konietschke, F., & Pauly, M. (2017). A wild bootstrap approach for nonparametric repeated measurements. *Computational Statistics & Data Analysis*, *113*(C), 38–52.

Friedrich, S., Konietschke, F., & Pauly, M. (2018). Analysis of Multivariate Data and Repeated Measures Designs with the R Package MANOVA.RM. *The R Journal*, *11*.

Galbrun, L., & Ali, T. T. (2013). Acoustical and perceptual assessment of water sounds and their use over road traffic noise. *The Journal of the Acoustical Society of America*, *133*(1), 227–237. https://doi.org/10.1121/1.4770242

Gauvreau, K., & Pagano, M. (1997). The Analysis of Correlated Binary Outcomes Using Multivariate Logistic Regression. *Biometrical Journal*, *39*(3), 309–325. https://doi.org/10.1002/bimj.4710390306

Gaver, W. W. (1993). What in the World Do We Hear?: An Ecological Approach to Auditory Event Perception. *Ecological Psychology*, *5*(1), 1–29. https://doi.org/10.1207/s15326969eco0501_1

Gough, B., & Madill, A. (2012). Subjectivity in psychological science: From problem to prospect. *Psychological Methods*, *17*(3), 374–384. https://doi.org/10.1037/a0029313

Gronbæk, K., Kortbek, K. J., Moller, C., Nielsen, J., & Stenfeldt, L. (2012). Designing playful interactive installations for urban environments-the swingscape experience. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *7624 LNCS*, 230–245. Scopus. https://doi.org/10.1007/978-3-642-34292-9-16

Guastavino, C. (2006). The Ideal Urban Soundscape: Investigating the Sound Quality of French Cities. *Acta Acustica United with Acustica*, *92*(6), 945–951.

Guastavino, C. (2018). Everyday Sound Categorization. In T. Virtanen, M. D. Plumbley, & D. Ellis (Eds.), *Computational Analysis of Sound Scenes and Events* (pp. 183–213). Springer International Publishing. https://doi.org/10.1007/978-3-319-63450-0_7

Guastavino, C. (2020, August 1). Current trends in urban soundscape research. *Internoise*. Internoise, Seoul, Korea.

Guastavino, C. (2021). Chapter 4. Exploring soundscapes. In *Sensory Experiences: Exploring meaning and the senses* (pp. 139–167). John Benjamins Publishing Company. https://doi.org/10.1075/celcr.24.04gua

Guastavino, C., Fraisse, V., D'Ambrosio, S., Legast, E., & Lavoie, M. (2022a). Designing Sound Installations in Public Spaces: A Collaborative Research- Creation Approach. In *Designing Interactions for Music and Sound*. Focal Press.

Guastavino, C., Fraisse, V., D'Ambrosio, S., Legast, E., & Lavoie, M. (2022b). Designing Sound Installations in Public Spaces: A Collaborative Research- Creation Approach. In *Designing Interactions for Music and Sound*. Focal Press.

Guastavino, C., Katz, B. F. G., Polack, J.-D., Levitin, D. J., & Dubois, D. (2005). Ecological Validity of Soundscape Reproduction. *Acta Acustica United with Acustica*, *91*(2), 333–341.

H4n Pro Four-Track Audio Recorder. (2023). https://zoomcorp.com/en/ca/handheld-recorders/handheld-recorders/h4n-pro/

Han, Z., Kang, J., & Meng, Q. (2023). Effect of sound sequence on soundscape emotions. *Applied Acoustics*, *207*, 109371. https://doi.org/10.1016/j.apacoust.2023.109371

Happ, M., Bathke, A. C., & Brunner, E. (2019). Optimal sample size planning for the Wilcoxon-Mann-Whitney test. *Statistics in Medicine*, *38*(3), 363–375. https://doi.org/10.1002/sim.7983

Hellström, B. (2011). Modelling the Shopping Soundscape. *Journal of Sonic Studies*, *01*. https://www.researchcatalogue.net/view/220808/220809

Hellstrom, B., Nilsson, M. E., Axelsson, Ö., & Lunden, P. (2014). Acoustic Design Artifacts and Methods for Urban Soundscapes: A Case Study on the Qualitative Dimensions of Sounds. *Journal of Architectural and Planning Research*, *31*(1), 57–71.

Herranz-Pascual, K., Aspuru, I., & Garcia, I. (2010, September 1). Proposed Conceptual Model of Environmental Experience as Framework to Study the Soundscape. *Proceedings of INTERNOISE*.

Hong, J. Y., He, J., Lam, B., Gupta, R., & Gan, W.-S. (2017). Spatial Audio for Soundscape Design: Recording and Reproduction. *Applied Sciences*, *7*(6), Article 6. https://doi.org/10.3390/app7060627

Hong, J. Y., Lam, B., Ong, Z.-T., Ooi, K., Gan, W.-S., Kang, J., Yeong, S., Lee, I., & Tan, S.-T. (2020). Effects of contexts in urban residential areas on the pleasantness and appropriateness of natural sounds. *Sustainable Cities and Society*, *63*, 102475. https://doi.org/10.1016/j.scs.2020.102475

Hong, J. Y., Ong, Z.-T., Lam, B., Ooi, K., Gan, W.-S., Kang, J., Feng, J., & Tan, S.-T. (2020). Effects of adding natural sounds to urban noises on the perceived loudness of noise and soundscape quality. *Science of The Total Environment*, *711*, 134571. https://doi.org/10.1016/j.scitotenv.2019.134571

Hong, J.-Y., & Chong, K. H. (2023). Designing Public Soundscapes through Social Architecture and Soundscape Approaches: Reflective Review of Architectural Design Studio. *Sustainability*, *15*(16), Article 16. https://doi.org/10.3390/su151612399

Hoop, M., Kirchberg, V., Kaddar, M., Barak, N., & de Shalit, A. (2022). Urban artistic interventions: A typology of artistic political actions in the city. *City, Culture and Society*, *29*, 100449. https://doi.org/10.1016/j.ccs.2022.100449

Hou, Y., Ren, Q., Zhang, H., Mitchell, A., Aletta, F., Kang, J., & Botteldooren, D. (2023). AI-based soundscape analysis: Jointly identifying sound sources and predicting annoyance. *The Journal of the Acoustical Society of America*, *154*(5), 3145–3157. https://doi.org/10.1121/10.0022408

Hsieh, C., Yang, J.-Y., Huang, C., & Chin, W. C. B. (2023). The effect of water sound level in virtual reality: A study of restorative benefits in young adults through immersive natural environments. *Journal of Environmental Psychology*, *88*, 102012. https://doi.org/10.1016/j.jenvp.2023.102012

ISO 1996-2. (2017). *ISO 1996-2:2017*. https://www.iso.org/standard/59766.html

ISO TS 12913-1. (2014). *Acoustics—Soundscape—Part 1: Definition and conceptual framework*. International Organization for Standardization.

ISO TS 12913-2. (2018). *Acoustics—Soundscape—Part 2: Data collection and reporting requirements*. International Organization for Standardization.

ISO TS 12913-3. (2019). *Acoustics—Soundscape—Part 3: Data analysis*. International Organization for Standardization.

ISO/AWI TS 12913-4. (2023). https://genorma.com/en/project/show/iso:proj:81507

Jambrošić, K., Horvat, M., & Domitrović, H. (2013). Assessment of urban soundscapes with the focus on an architectural installation with musical features. *Journal of the Acoustical Society of America*, *134*(1), 869–879. Scopus. https://doi.org/10.1121/1.4807805

Jeon, J. Y., Lee, P. J., You, J., & Kang, J. (2010). Perceptual assessment of quality of urban soundscapes with combined noise sources and water sounds. *The Journal of the Acoustical Society of America*, *127*(3), 1357–1366. https://doi.org/10.1121/1.3298437

Jeon, J. Y., Lee, P. J., You, J., & Kang, J. (2012). Acoustical characteristics of water sounds for soundscape enhancement in urban open spaces. *The Journal of the Acoustical Society of America*, *131*(3), 2101–2109. https://doi.org/10.1121/1.3681938

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika*, *39*(1), 31–36. https://doi.org/10.1007/BF02291575

Kang, J. (2006). *Urban Sound Environment*. CRC Press. https://doi.org/10.1201/9781482265613

Kang, J., Aletta, F., Gjestland, T. T., Brown, L. A., Botteldooren, D., Schulte-Fortkamp, B., Lercher, P., van Kamp, I., Genuit, K., Fiebig, A., Bento Coelho, J. L., Maffei, L., & Lavia, L. (2016). Ten questions on the soundscapes of the built environment. *Building and Environment*, *108*, 284–294. https://doi.org/10.1016/j.buildenv.2016.08.011

Kang, J., & Schulte-Fortkamp, B. (2015). *Soundscape and the Built Environment*. CRC Press.

Kihm, C. (2020). Art sonore ou art d'écouter ? *Circuit : musiques contemporaines*, *30*(1), 25–39. https://doi.org/10.7202/1069081ar

Klein, G. (2009). Site-sounds: On strategies of sound art in public space. *Organised Sound*, *14*(1), 101–108. Scopus. https://doi.org/10.1017/S1355771809000132

Kong, Q., Cao, Y., Iqbal, T., Wang, Y., Wang, W., & Plumbley, M. D. (2020). *PANNs: Large-Scale Pretrained Audio Neural Networks for Audio Pattern Recognition* (arXiv:1912.10211). arXiv. https://doi.org/10.48550/arXiv.1912.10211

Krause, B. (1993). The Niche Hypothesis: A virtual symphony of animal sounds, the origins of musical expression and the health of habitats. *Soundscape Newsletter (World Forum for Acoustic Ecology)*.

LaBelle, B. (2006). *Background Noise: Perspectives on Sound Art* (1th Edition). Bloomsbury Academic.

LaBelle, B. (2018). *Sonic Agency: Sound and Emergent Forms of Resistance*. Goldsmiths Press.

Lacey, J. (2016a). Sonic Placemaking: Three approaches and ten attributes for the creation of enduring urban sound art installations. *Organised Sound*, *21*(2), 147–159. Scopus. https://doi.org/10.1017/S1355771816000078

Lacey, J. (2016b). *Sonic Rupture: A Practice-led Approach to Urban -Soundscape Design*. Bloomsbury Academic. https://doi.org/10.5040/9781501309984

Lacey, J. (2019). Thoughts towards a Fourth Phase of Soundscape Research: (Re)merging quantitative and artistic practice. *Internoise*. Internoise, Madrid, Spain.

Lacey, J., Pink, S., Harvey, L., & Moore, S. (2019). Noise transformation: A critical listening-based methodology for the design of motorway soundscapes. *Qualitative Research Journal*, *19*(1), 49–64. https://doi.org/10.1108/QRJ-D-17-00018

Landy, L. (2007). *Understanding the Art of Sound Organization*. The MIT Press.

Lavandier, C., & Defreville, B. (2006). The contribution of sound source characteristics in the assessment of urban soundscapes. *Acta Acustica United with Acustica*, *92*, 912–921.

Lavia, L., Kang, J., Witchel, H., & Aletta, F. (2016). A preliminary soundscape management model for added sound in public spaces to discourage anti-social and support pro-social effects on public behaviour. *Proceedings of the DAGA*. http://dx.doi.org/10.13140/RG.2.1.1392.4242

Léchot Hirt, L. (2015). Recherche-création en design à plein régime: Un constat, un manifeste, un programme. *Sciences du Design*, *1*(1), 37–44. https://doi.org/10.3917/sdd.001.0037

Lee, H. M., & Lee, H. P. (2020). Noise masking in high population country using sound of water fountain. *Applied Acoustics*, *162*, 107206. https://doi.org/10.1016/j.apacoust.2020.107206

Lemaitre, G., Houix, O., Misdariis, N., & Susini, P. (2010). Listener expertise and sound identification influence the categorization of environmental sounds. *Journal of Experimental Psychology: Applied*, *16*(1), 16–32.

Lepore, F., Kostara-Konstantinou, E., Aletta, F., Astolfi, A., & Kang, J. (2016). A preliminary investigation about the influence of soundscapes on people's behaviour in an open public space. *Proceedings of INTERNOISE*, 5219–5224. Scopus.

Li, H., & Lau, S.-K. (2020). A review of audio-visual interaction on soundscape assessment in urban built environments. *Applied Acoustics*, *166*, 107372. https://doi.org/10.1016/j.apacoust.2020.107372

Licht, A. (2009). Sound Art: Origins, development and ambiguities. *Organised Sound*, *14*(1), 3–10. https://doi.org/10.1017/S1355771809000028

Licitra, G., Cobianchi, M., & Brusci, L. (2010). Artificial soundscape approach to noise pollution in urban areas. *Proceedings of INTERNOISE*, *4*, 2498–2507. Scopus.

Livingston, H. (2016). Listening in the Rose Garden. *Leonardo Music Journal*, *26*, 83–86. Scopus. https://doi.org/10.1162/LMJ_a_00981

Lugten, M., Karacaoglu, M., White, K., Kang, J., & Steemers, K. (2018). Improving the soundscape quality of urban areas exposed to aircraft noise by adding moving water and vegetation. *The Journal of the Acoustical Society of America*, *144*(5), 2906–2917. https://doi.org/10.1121/1.5079310

Lydon, M., & Garcia, A. (2015). *Tactical Urbanism: Short-term Action for Long-term Change* (Illustrated édition). Island Press.

Ma, K. W., Mak, C. M., & Wong, H. M. (2021). Effects of environmental sound quality on soundscape preference in a public urban space. *Applied Acoustics*, *171*, 107570. https://doi.org/10.1016/j.apacoust.2020.107570

Mair, P., Borg, I., & Rusch, T. (2016). Goodness-of-Fit Assessment in Multidimensional Scaling and Unfolding. *Multivariate Behavioral Research*, *51*(6), 772–789. https://doi.org/10.1080/00273171.2016.1235966

Meng, Q., & Kang, J. (2016). Effect of sound-related activities on human behaviours and acoustic comfort in urban open spaces. *Science of The Total Environment*, *573*, 481–493. https://doi.org/10.1016/j.scitotenv.2016.08.130

Meng, Q., Zhao, T., & Kang, J. (2018). Influence of Music on the Behaviors of Crowd in Urban Open Public Spaces. *Frontiers in Psychology*, *9*.

Mhacoustics.com. (2023). https://mhacoustics.com/products

Milo, A. (2020). The acoustic designer: Joining soundscape and architectural acoustics in architectural design education. *Building Acoustics*, *27*(2), 83–112. https://doi.org/10.1177/1351010X19893593

MILSON. (2024). *Info*. https://milson.fr/contacts/

Moreau, S. (2006). *Étude et réalisation d'outils avancés d'encodage spatial pour la technique de spatialisation sonore Higher Order Ambisonics: Microphone 3D et contrôle de distance* [PhD Thesis]. Université du Mans.

Morel, J., Marquis-Favre, C., Dubois, D., & Pierrette, M. (2012). Road Traffic in Urban Areas: A Perceptual and Cognitive Typology of Pass-By Noises. *Acta Acustica United with Acustica*, *98*(1), 166–178. https://doi.org/10.3813/AAA.918502

Moshona, C., Aletta, F., Henze, H., Chen, X., Mitchell, A., Oberman, T., Tong, H., Fiebig, A., Kang, J., & Schulte-Fortkamp, B. (2022, August 24). What is a soundscape intervention? Exploring definitions and identification criteria and a platform to gather real-world examples. *Proceedings of INTERNOISE*.

Moshona, C. C., Fiebig, A., Aletta, F., Chen, X., Kang, J., Mitchell, A., Oberman, T., & Schulte-Fortkamp, B. (2024). A framework to characterize and classify soundscape design practices based on grounded theory. *Noise Mapping*, *11*(1). https://doi.org/10.1515/noise-2024-0002

Neuhaus, M., & Des Jardins, G. (1994). *Sound works: Volume I*. Cantz Verlag.

Neuhaus, M., Hug, X., & Balit, D. (2018). *Les pianos ne poussent pas sur les arbres* (M. Verry, Trans.). Les Presses du réel.

Nilsson, M. E., Alvarsson, J., Rådsten-Ekman, M., & Bolin, K. (2010). Auditory masking of wanted and unwanted sounds in a city park. *Noise Control Engineering Journal*, *58*(5), 524–531. https://doi.org/10.3397/1.3484182

NVivo. (2024). Lumivero. https://lumivero.com/products/nvivo/

Oberman, T., Jambrošić, K., Horvat, M., & Bojanić Obad Šćitaroci, B. (2020). Using Virtual Soundwalk Approach for Assessing Sound Art Soundscape Interventions in Public Spaces. *Applied Sciences*, *10*(6), Article 6. https://doi.org/10.3390/app10062102

Ong, Z. T., Hong, J., Lam, B., Ooi, K., Gan, W.-S., Yeong, S., Lee, I., & Tan, S.-T. (2019, September 1). Prediction models of desirable levels of birdsong and water sound in a noisy environment: A laboratory experiment based on virtual reality. *Proceedings of the International Congress on Acoustics*. https://doi.org/10.18154/RWTH-CONV-239595

Ooi, K., Ong, Z.-T., Watcharasupat, K. N., Lam, B., Hong, J. Y., & Gan, W.-S. (2024). ARAUS: A Large-Scale Dataset and Baseline Models of Affective Responses to Augmented Urban Soundscapes. *IEEE Transactions on Affective Computing*, *15*(1), 105–120. https://doi.org/10.1109/TAFFC.2023.3247914

Ooi, K., Watcharasupat, K. N., Lam, B., Ong, Z.-T., & Gan, W.-S. (2022). Probably Pleasant? A Neural-Probabilistic Approach to Automatic Masker Selection for Urban Soundscape Augmentation. *ICASSP 2022 - 2022 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, 8887–8891. https://doi.org/10.1109/ICASSP43922.2022.9746897

Ouzounian, G. (2021). *Stereophonica: Sound and Space in Science, Technology, and the Arts*. The MIT Press.

Parker, M., & Spennemann, D. H. R. (2022). Classifying Sound: A Tool to Enrich Intangible Heritage Management. *Acoustics Australia*, *50*(1), 23–39. https://doi.org/10.1007/s40857-021-00257-y

Payne, S. R. (2013). The production of a Perceived Restorativeness Soundscape Scale. *Applied Acoustics*, *74*(2), 255–263. https://doi.org/10.1016/j.apacoust.2011.11.005

Payne, S. R., & Guastavino, C. (2018). Exploring the Validity of the Perceived Restorativeness Soundscape Scale: A Psycholinguistic Approach. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.02224

Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology*, *49*(12), 1373–1379. https://doi.org/10.1016/S0895-4356(96)00236-3

Pink, S., Lacey, J., Harvey, L., Sumartojo, S., Duque, M., & Moore, S. (2019). Recycling traffic noise: Transforming sonic automobilities for revalue and well being. *Mobilities*, *14*(2), 233–249. https://doi.org/10.1080/17450101.2018.1548882

Poirier-Quinot, D., Katz, B. F. G., & Noisternig, M. (2017). EVERTims: Open source framework for real-time auralization in architectural acoustics and virtual reality. *Proceedings of the DAFx-17*.

Prado, G., & Mazzarotto, M. (2024). If This Street Was Ours: Provoking the Reimagination of the City as a Democratic Space. *DRS Biennial Conference Series*. https://dl.designresearchsociety.org/drs-conference-papers/drs2024/researchpapers/64

Puyana-Romero, V., Maffei, L., Brambilla, G., & Nuñez-Solano, D. (2021). Sound Water Masking to Match a Waterfront Soundscape with the Users' Expectations: The Case Study of the Seafront in Naples, Italy. *Sustainability*, *13*(1), Article 1. https://doi.org/10.3390/su13010371

Rådsten Ekman, M., Lundén, P., & Nilsson, M. E. (2015). Similarity and pleasantness assessments of water-fountain sounds recorded in urban public spaces. *The Journal of the Acoustical Society of America*, *138*(5), 3043–3052. https://doi.org/10.1121/1.4934956

Ratcliffe, E. (2021). Sound and Soundscape in Restorative Natural Environments: A Narrative Literature Review. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.570563

Reaper. (2023). https://www.reaper.fm/

Reathon. (2023). https://github.com/jamesb93/reathon (Original work published 2021)

Revelle, W. (2022). *psych: Procedures for Psychological, Psychometric, and Personality Research* (Version 2.2.9) [Computer software]. https://CRAN.R-project.org/package=psych

Robson, N., Bryan-Kinns, N., & McPherson, A. (2023). On Mediating Space, Sound and Experience: Interviews with situated sound art practitioners. *Organised Sound*, *28*(1), 25–34. https://doi.org/10.1017/S1355771822000103

Røde. (2024). *RØDE Blimp | Windshield and Shock Mount System | RØDE*. https://rode.com/en/accessories/windshields/blimp

Rönnberg, N., & Löwgren, J. (2021). Designing the user experience of musical sonification in public and semi-public spaces. *SoundEffects - An Interdisciplinary Journal of Sound and Sound Experience*, *10*(1), Article 1. https://doi.org/10.7146/se.v10i1.124202

Rosenthal, R. (1991). *Meta-analytic procedures for social research, Rev. Ed* (pp. x, 155). Sage Publications. https://doi.org/10.4135/9781412984997

Rosi, V. (2022). *The Metaphors of Sound: From Semantics to Acoustics. A Study of Brightness, Warmth, Roundness, and Roughness* [PhD Thesis, Sorbonne Université]. https://theses.hal.science/tel-03994903

Rudi, J. (2005). 'From a Musical Point of View, the World is Musical at any given Moment': An Interview with Bill Fontana. *Organised Sound*, *10*(2), 97–101. Scopus. https://doi.org/10.1017/s1355771805000737

Russolo, L. (1913). *The Art of Noise (translated from L'arte dei Rumori)* (F. Robert, Trans.). Something Else press.

Sarwono, J., Sudarsono, A. S., Hapsari, A., Salim, H., & Tassia, R. D. (2022). The Implementation of Soundscape Composition to Identify the Ideal Soundscape for

Various Activities. *Journal of Engineering and Technological Sciences*, *54*(1), Article 1. https://doi.org/10.5614/j.eng.technol.sci.2022.54.1.7

Schaeffer, P. (1966). *Traité Des Objets Musicaux*. Le Seuil.

Schafer, R. M. (1977). *The Tuning of the World*. Knopf.

Schroeder, M. R. (1962). Natural Sounding Artificial Reverberation. *Journal of the Audio Engineering Society*, *10*(3), 219–223.

Schütz, N. (2017). *Cultivating Sound: The Acoustic Dimension of Landscape Architecture* [Doctoral Thesis, ETH Zurich]. https://doi.org/10.3929/ethz-b-000242058

Seay, J. (2014). Engaging the audience: A primer for sound art in public spaces. *Leonardo Music Journal*, *24*, 77–78. Scopus. https://doi.org/10.1162/LMJ_a_00213

Sennheiser. (2024). *Stereo shotgun microphone MKH 418-S | Sennheiser*. https://www.sennheiser.com/en-us/catalog/products/microphones/mkh-418/mkh-418-s-005284

Southworth, M. (1969). The Sonic Environment of Cities. *Environment and Behavior*, *1*(1), 49–70. https://doi.org/10.1177/001391656900100104

Spat | Ircam Forum. (2023). https://forum.ircam.fr/projects/detail/spat/

Stappers, P. J., & Giaccardi, E. (2014). Research through Design. In *The Encyclopedia of Human-Computer Interaction* (2nd ed.). Interaction Design Foundation. https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/research-through-design

stats package—RDocumentation. (2023). https://www.rdocumentation.org/packages/stats/versions/3.6.2

Steele, D., Bild, E., & Guastavino, C. (2023). Moving past the sound-noise dichotomy: How professionals of the built environment approach the sonic dimension. *Cities*, *132*, 103974. https://doi.org/10.1016/j.cities.2022.103974

Steele, D., Bild, E., Tarlao, C., & Guastavino, C. (2019). Soundtracking the Public Space: Outcomes of the Musikiosk Soundscape Intervention. *International Journal of Environmental Research and Public Health*, *16*(10), Article 10. https://doi.org/10.3390/ijerph16101865

Steele, D., Fraisse, V., Bild, E., & Guastavino, C. (2021). Bringing music to the park: The effect of Musikiosk on the quality of public experience. *Applied Acoustics*, *177*, 107910. https://doi.org/10.1016/j.apacoust.2021.107910

Steele, D., & Guastavino, C. (2021). Quieted City Sounds during the COVID-19 Pandemic in Montreal. *International Journal of Environmental Research and Public Health*, *18*(11), Article 11. https://doi.org/10.3390/ijerph18115877

Steele, D., Kerrigan, C., & Guastavino, C. (2020). Sounds in the city: Bridging the gaps from research to practice through soundscape workshops. *Journal of Urban Design*, *25*(5), 646–664. https://doi.org/10.1080/13574809.2019.1699399

Steele, D., Legast, É., Trudeau, C., Fraisse, V., & Guastavino, C. (2019). Sounds in the City: Improving the soundscape of a public square through sound art. *International Congress on Sound and Vibration*.

Steinmetz, C. J., & Reiss, J. D. (2021). pyloudnorm: A simple yet flexible loudness meter in Python. *Proceedings of the AES Convention*, 8.

Sudarsono, A. S., Lam, Y. W., & Davies, W. J. (2016). The effect of sound level on perception of reproduced soundscapes. *Applied Acoustics*, *110*, 53–60. https://doi.org/10.1016/j.apacoust.2016.03.011

Tarlao, C., Aumond, P., Lavandier, C., & Guastavino, C. (2023). Converging towards a French translation of soundscape attributes: Insights from Quebec and France. *Applied Acoustics*, *211*, 109572. https://doi.org/10.1016/j.apacoust.2023.109572

Tarlao, C., Leclerc, F., Brochu, J., & Guastavino, C. (2024). Current approaches to planning (with) sound. *Science of The Total Environment*, *931*, 172826. https://doi.org/10.1016/j.scitotenv.2024.172826

Tarlao, C., Steele, D., Blanc, G., & Guastavino, C. (2023). Interactive soundscape simulation as a co-design tool for urban professionals. *Landscape and Urban Planning*, *231*, 104642. https://doi.org/10.1016/j.landurbplan.2022.104642

Tarlao, C., Steele, D., & Guastavino, C. (2019, June 17). Investigating Factors Influencing Soundscape Evaluations Across Multiple Urban Spaces In Montreal. *Proceedings of Internoise*.

Tarlao, C., Steele, D., & Guastavino, C. (2022). Assessing the ecological validity of soundscape reproduction in different laboratory settings. *PLOS ONE*, *17*(6), e0270401. https://doi.org/10.1371/journal.pone.0270401

Tarlao, C., Steffens, J., & Guastavino, C. (2021). Investigating contextual influences on urban soundscape evaluations with structural equation modeling. *Building and Environment*, *188*, 107490. https://doi.org/10.1016/j.buildenv.2020.107490

Tate. (2024). *Site-specific*. Tate. https://www.tate.org.uk/art/art-terms/s/site-specific

The CSI Project Team. (2023). *The Catalogue of Soundscape Interventions (CSI)*. https://soundscape-intervention.org/

Tittel, C. (2009). Sound art as sonification, and the artistic treatment of features in our surroundings. *Organised Sound*, *14*(1), 57–64. Scopus. https://doi.org/10.1017/S1355771809000089

Torehammar, C., & Hellström, B. (2012). Nine sound-art installations in public space. *Proceedings of INTERNOISE*, *3*, 2132–2140. Scopus.

Truax, B. (1984). *Acoustic Communication* (0 ed.). Ablex Publishing Corporation.

Trudeau, C., Steele, D., Dumoulin, R., & Guastavino, C. (2018). Sounds in the city: Differences in urban noise management strategies across cities. *Proceedings of Internoise*.

Trudeau, C., Steele, D., & Guastavino, C. (2020). A Tale of Three Misters: The Effect of Water Features on Soundscape Assessments in a Montreal Public Space. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.570797

Trudeau, C., Tarlao, C., & Guastavino, C. (2023). Montreal soundscapes during the COVID-19 pandemic: A spatial analysis of noise complaints and residents' surveys. *Noise Mapping*, *10*(1). https://doi.org/10.1515/noise-2022-0169

United Nations Environment Programme. (2022). *Noise, Blazes, and Mismatches: Emerging Issues of Environmental Concern*.

Van Renterghem, T., Vanhecke, K., Filipan, K., Sun, K., De Pessemier, T., De Coensel, B., Joseph, W., & Botteldooren, D. (2020). Interactive soundscape augmentation by natural sounds in a noise polluted urban park. *Landscape and Urban Planning*, *194*, 103705. https://doi.org/10.1016/j.landurbplan.2019.103705

Vogel, C. (2013). A situated sound art: Meaning and space. *Etnografica*, *17*(3), 605–616. Scopus. https://doi.org/10.4000/etnografica.3260

Welch, D., Shepherd, D., Dirks, K., Tan, M. Y., & Coad, G. (2019). Use of Creative Writing to Develop a Semantic Differential Tool for Assessing Soundscapes. *Frontiers in Psychology*, *9*, 2698. https://doi.org/10.3389/fpsyg.2018.02698

What is Max? | Cycling '74. (2023). https://cycling74.com/products/max

What's New in Live 11. (2024). Ableton. https://help.ableton.com/hc/en-us/articles/6014390521756-What-s-New-in-Live-11

Wilcoxon Effect Size—Wilcox_effsize. (n.d.). Retrieved March 2, 2023, from https://rpkgs.datanovia.com/rstatix/reference/wilcox_effsize.html

World Health Organization. (2022). *Environmental Noise* (Compendium of WHO and Other UN Guidance on Health and Environment).

World Health Organization, Regional office for Europe. (2011). *Burden of disease from environmental noise: Quantification of healthy life years lost in Europe.*

Xiao, J., Aletta, F., & Ali-Maclachlan, I. (2022). On the Opportunities of the Soundscape Approach to Revitalise Acoustics Training in Undergraduate Architectural Courses. *Sustainability*, *14*(4), Article 4. https://doi.org/10.3390/su14041957

Yanaky, R., Tyler, D., & Guastavino, C. (2023). City Ditty: An Immersive Soundscape Sketchpad for Professionals of the Built Environment. *Applied Sciences*, *13*, 1611. https://doi.org/10.3390/app13031611

Yang, J., & Lu, H. (2022). Visualizing the Knowledge Domain in Urban Soundscape: A Scientometric Analysis Based on CiteSpace. *International Journal of Environmental Research and Public Health*, *19*(21), Article 21. https://doi.org/10.3390/ijerph192113912

Yang, W., & Kang, J. (2005). Acoustic comfort evaluation in urban open public spaces. *Applied Acoustics*, *66*(2), 211–229. https://doi.org/10.1016/j.apacoust.2004.07.011

Yee, T. W. (2015). VGLMs. In T. W. Yee (Ed.), *Vector Generalized Linear and Additive Models: With an Implementation in R* (pp. 91–126). Springer. https://doi.org/10.1007/978-1-4939-2818-7_3

Zhang, S., & Chen, L. (2023). Acoustic information masking effects of natural sounds on traffic noise based on psychological health in open urban spaces. *Frontiers in Public Health*, *11*, 1031501. https://doi.org/10.3389/fpubh.2023.1031501

Zhao, W., Li, H., Zhu, X., & Ge, T. (2020). Effect of Birdsong Soundscape on Perceived Restorativeness in an Urban Park. *International Journal of Environmental Research and Public Health*, *17*(16), Article 16. https://doi.org/10.3390/ijerph17165659

Zotter, F., Pomberger, H., & Noisternig, M. (2012). Energy-Preserving Ambisonic Decoding. *Acta Acustica United with Acustica*, *98*, 37–47. https://doi.org/10.3813/AAA.918490

APPENDICES

Appendix A. Chapter 2: Audio excerpts, semantic classes and statistical tables

Audio excerpts for each of the sound installations are available in the online version of (Fraisse, Tarlao, et al., 2024) and in the Catalogue of Soundscape Interventions (The CSI Project Team, 2023):

https://soundscape-intervention.org/ex-place-des-fleurs-de-macadam/

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, ron-ron du scooter
OTHER TRAFFIC	jet engine from planes, planes, airplanes	klaxon de bateau, des bruits qui ressemble à un bateau, avions, bateau qui tangue, 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, géneratrice
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 jasent, 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'amusent, phrases, femme au téléphone, hurlements
HUMAN MOVEMENT	bags of bottles, gravel, people dragging their feet, footsteps, rockyfloor, 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 gougoune, 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 A.1. Emerging semantic classes of sound sources, using Brown and colleagues' classification scheme (Kang & Schulte-Fortkamp, 2015).

	Design A – Woodlands, lower half of the space (N=57)		Design B – Voices (N=186)	
Soundscape Scale	p	r	p	r
Pleasant	.55	.11	.44	.09
Appropriate	.10	.27	.58	.05
Calm	.0778	.31	**.0245**	**.20**
Being-away	.0778	.30	.46	.07
Eventful	.43	.14	.58	.05
Vibrant	.21	.21	.24	.13
Loudness	**.0296**	**.39**	**.0092**	**.24**
Chaotic	.74	.06	.46	.08
Monotonous	.74	.05	.85	.01

Table A.2. 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 Benjamini-Hochberg post-hoc Mann-Whitney U tests. Significant results at p < .05 in bold.

Condition	Location	Valence	Variable	Estimate (SE)	p
A - Woodlands	Upper half (N=82)	Pleasant	VOICE	0.46(0.45)	.30
			BIRDS	0.21(0.49)	.67
			HUMAN MOVEMENT	**-1.69(0.68)**	**.0131**
			WIND	0.67(0.58)	.25
		Neutral	VOICE	0.20(0.50)	.69
			TRAFFIC	**-2.43(0.79)**	**.0021**
		Unpleasant	TRAFFIC	1.23(0.70)	.08
	Lower half (N=54)	Pleasant	VOICE	0.40(0.56)	.47
			BIRDS	**-1.46(0.62)**	**.0194**
			HUMAN MOVEMENT	0.68(0.71)	.34
			WATER	-0.37(0.56)	.51
		Neutral	VOICE	0.19(0.66)	.77
			TRAFFIC	-0.19(0.63)	.76
		Unpleasant	TRAFFIC	-0.39(0.61)	.52

Table A.3. 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 < .05 in bold.

Condition	Valence	Variable	Estimate (SE)	p
B - Voices	Pleasant	VOICE	-0.31(0.31)	.32
		WIND	-0.38(0.36)	.30
		HUMAN MOVEMENT	-0.38(0.40)	.35
		WATER	-0.84(0.55)	.13
		BIRDS	0.22(0.53)	.67
		MUSIC	**3.03(1.05)**	**.0038**
		ROAD	0.22(0.65)	.74
	Neutral	TRAFFIC	0.13(0.36)	.71
		VOICE	0.06(0.37)	.87
		HUMAN MOVEMENT	0.63(0.45)	.16
	Unpleasant	TRAFFIC	-0.51(0.35)	.55

Table A.4. 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 < .05 in bold.

	No intervention – Synthesizers (N=105)		No intervention – Seascape (N=74)		Synthesizers – Seascape (N=91)	
Soundscape Scale	p	r	p	r	p	r
Pleasant	**.0054**	**.38**	**.0282**	**.35**	.80	.05
Appropriate	.74	.13	.74	.11	.87	.02
Calm	**.0054**	**.37**	**.0334**	**.34**	.75	.06
Compatibility	.22	.22	.49	.15	.81	.03
Extent-coherence	**.0282**	**.32**	.15	.26	.74	.07
Being-away	.43	.18	.81	.03	.43	.15
Eventful	.31	.20	.80	.05	.45	.15
Vibrant	.74	.06	.22	.24	.09	.29
Fascination	.44	.14	.43	.22	.74	.07
Loudness	.15	.25	.43	.18	.56	.10
Chaotic	**.0007**	**.44**	.31	.18	.31	.19
Monotonous	.81	.06	.81	.10	.81	.03

Table A.5. 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 Benjamini-Hochberg post-hoc Mann-Whitney U tests. Significant results at p < .05 in bold.

Period	Condition	Valence	Variable	Estimate (SE)	p
During Construction	C - Synthesizers	Pleasant	BIRDS	-0.70(0.46)	.12
			VOICE	**-1.17(0.52)**	**.0244**
		Neutral	TRAFFIC	-0.44(0.53)	.41
		Unpleasant	TRAFFIC	-0.48(0.50)	.17
			CONSTRUCTION	**-1.15(0.44)**	**.0084**
	C - Seascape	Pleasant	**BIRDS**	**1.01(0.50)**	**.0440**
			VOICE	-0.67(0.56)	.23
		Neutral	TRAFFIC	-0.60(0.65)	.36
		Unpleasant	TRAFFIC	-0.48(0.50)	.33
			CONSTRUCTION	**-1.01(0.50)**	**.0440**
Outside Construction	C - Synthesizers	Pleasant	**BIRDS**	**-0.99(0.29)**	**.0006**
			MUSIC	**1.85(0.35)**	**<.0001**
			VOICE	**-0.71(0.31)**	**.0224**
			WIND	0.52(0.35)	.14
		Neutral	VOICE	-0.15(0.33)	.64
			TRAFFIC	0.18(0.35)	.61
			HUMAN MOVEMENT	0.27(0.47)	.56
		Unpleasant	**TRAFFIC**	**-1.02(0.28)**	**.0003**
			AIR CONDITIONER	**-0.79(0.33)**	**.0166**
			VOICE	-0.56(0.56)	.31
			CONSTRUCTION	-0.25(0.59)	.67
	C - Seascape	Pleasant	BIRDS	-0.48(0.29)	.10
			MUSIC	0.20(0.42)	.63
			VOICE	-0.54(0.32)	.09
			WIND	0.10(0.39)	.79
		Neutral	VOICE	0.41(0.33)	.68
			TRAFFIC	0.35(0.36)	.33
			HUMAN MOVEMENT	-0.29(0.56)	.61
		Unpleasant	TRAFFIC	-0.46(0.29)	.11
			AIR CONDITIONER	**-1.18(0.39)**	**.0024**
			VOICE	-0.12(0.54)	.82
			CONSTRUCTION	0.33(0.56)	.55

Table A.6. 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 $p < .05$ in bold.

Appendix B. Chapter 3: Audio excerpts and analysis code

The analysis code as well as the python script used to generate the randomized baseline audio are available in the link below:

https://github.com/valerianF/analysis_codes/blob/main/JASA_Using_Soundscape_Simulation

Audio excerpts are available in the online version of (Fraisse, Schütz, et al., 2024):

https://doi.org/10.1121/10.0028184

Appendix C. Chapter 4: Spectrogram of the conditions, interview guide and instruction sheet

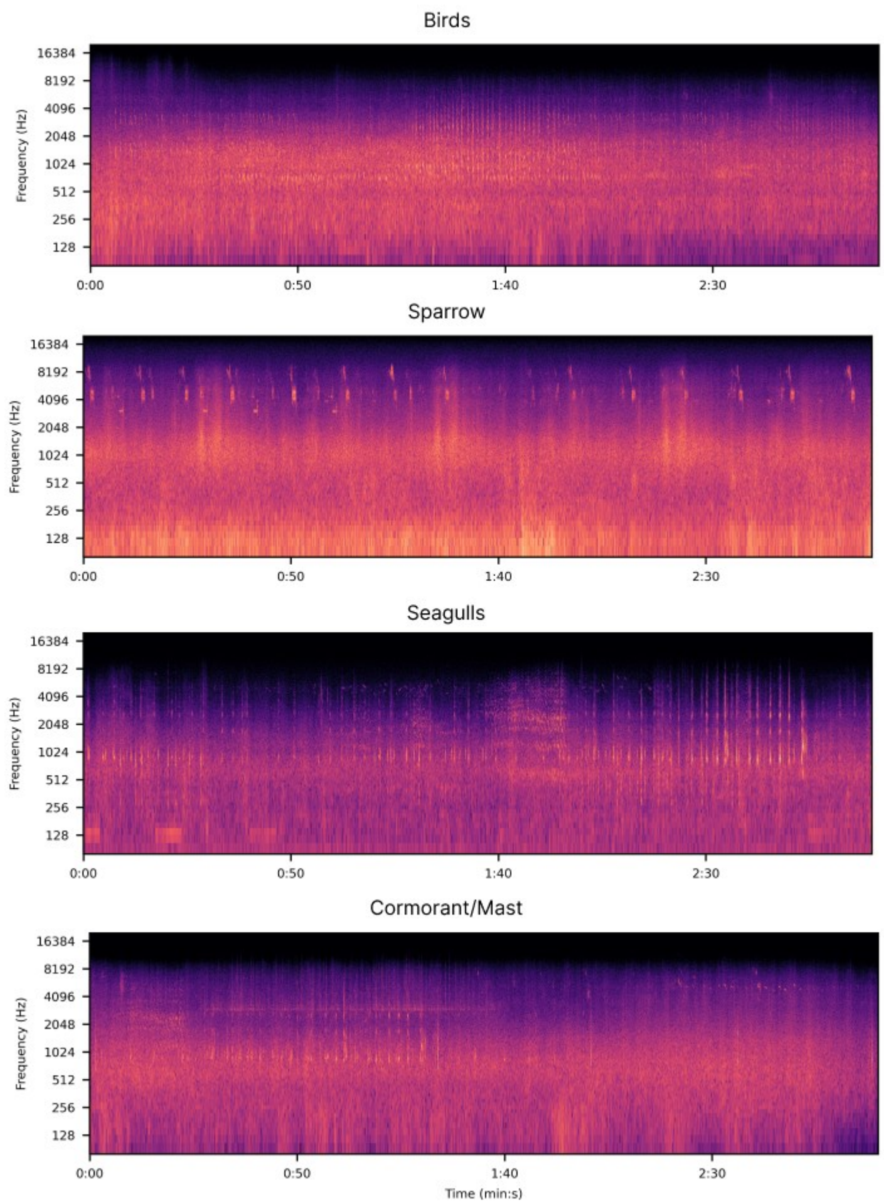


Figure C.1. Spectrograms of the Birds dominant conditions (left and right channels are averaged), made with python's librosa library. FFT size: 2048; Hanning window; hop length: 512. The spectrograms of all 11 compositions are normalized.

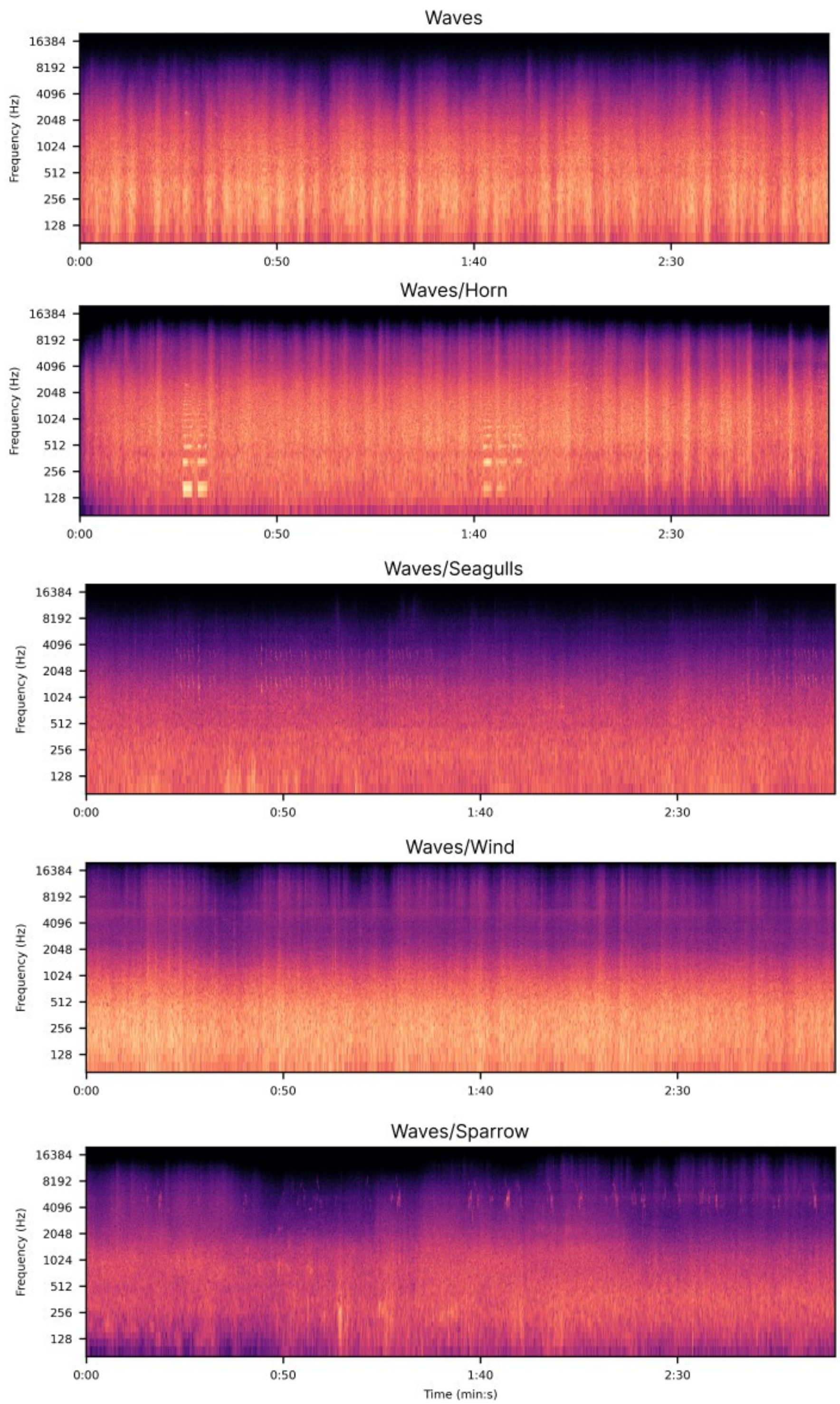


Figure C.2. Spectrograms of the Water/Wind dominant and hybrids conditions (left and right channels are averaged), made with python's librosa library. FFT size: 2048; Hanning window; hop length: 512. The spectrograms of all 11 compositions are normalized.

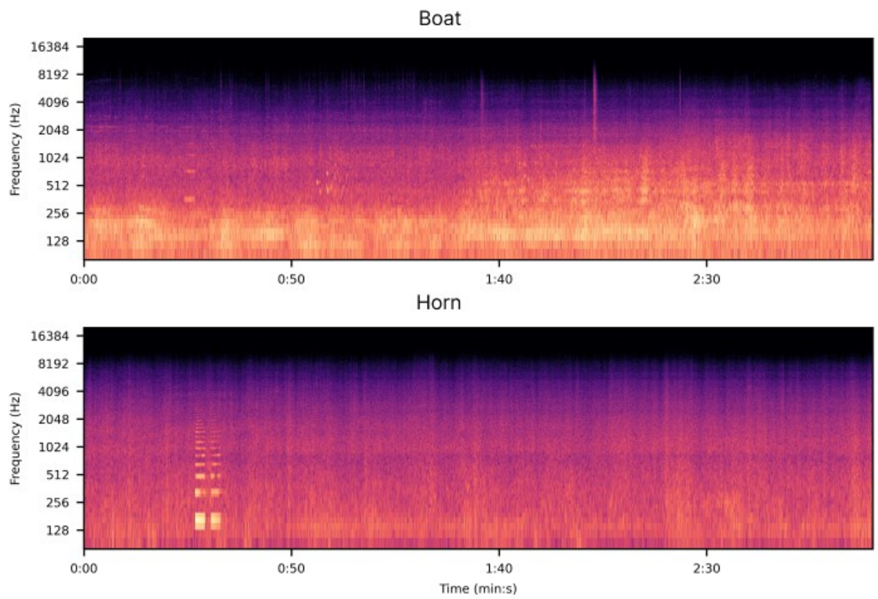


Figure C.3. Spectrograms of the Boat dominant conditions (left and right channels are averaged), made with python's librosa library. FFT size: 2048; Hanning window; hop length: 512. The spectrograms of all 11 compositions are normalized.

Question (EN)	Question (FR)
Generally speaking, how do you feel about these listening sessions?	*De manière générale, quel est votre ressenti par rapport à ces écoutes ?*
Were there any remarkable, out of the ordinary soundscapes during your listening?	*Durant vos écoutes, est-ce qu'il y a eu des moments marquants, qui sortent de l'ordinaire ?*
Now we will listen again to the significant moments you identified during the experiment:	Nous allons maintenant réecouter les moments marquants que vous avez identifié lors de l'expérience:
Why was this a significant moment for you?	*Pourquoi ce moment a été marquant pour vous ?*
Could you describe how you feel about this moments?	*Pouvez-vous décrire votre ressenti sur ce moment ?*
Does this moment correspond to a desirable experience in the Parc des Madelinots?	*Est-ce que ce moment correspond à une expérience souhaitable sur le Parc des Madelinots ?*
The next questions are no longer about the significant moments, but about all the experiment and the Parc des Madelinots itself.	Les prochaines questions ne concernent plus les moments marquants, mais l'ensemble des écoutes que vous avez faites ainsi que le Parc des Madelinots.
Are the added sounds harmoniously integrated with the existing sound environment?	*Est-ce que les sons ajoutés si vous en avez remarqué s'intègrent de manière harmonieuse avec l'environnement sonore existant ?*
Do you belong to the Madelinean community, or have you any significant link with the îles-de-la-Madeleine? If yes, do the added sounds evoke the îles de la Madeleine to you? If so, which ones? Would these sounds help you reconnect with the îles de la Madeleine?	*Est-ce que vous appartenez à la communauté Madelinéene ou possédez un lien particulier avec les îles-de-la-Madeleine ? If ye, est-ce que les sons ajoutés vous évoquent les îles de la Madeleine ? Si oui, lesquels ? Est-ce que ces sons pourraient vous aider à vous reconnecter avec les îles de la Madeleine ?*
What would you like to hear in this space that was missing in this experiment?	*Qu'aimeriez-vous entendre dans cet espace, et qui manquait dans cette expérience ?*
What brings you to the parc des Madelinots?	*Qu'est-ce qui vous amène sur le Parc des Madelinots ?*
Would any of the soundscapes you heard incite you to spend more time or to do activities in the Parc des Madelinots that you don't already do?	*Est-ce que les ambiances entendues pourraient vous inciter à passer plus de temps ou à faire d'autres activités sur le Parc des Madelinots ?*
What do you think about the parc des Madelinots?	*Que pensez-vous du parc des Madelinots ?*
Do you know about the sound installation Les Madelinéennes? If so, are you aware of its artistic intentions?	*Avez-vous connaissance du projet d'installation sonore Les Madelinéennes qui se trouve au Parc des Madelinots ? Si oui, connaissez-vous les intentions artistiques de cette œuvre ?*
Do you have any comments, anything to add?	*Avez-vous des commentaires, quelque chose à ajouter ?*

Table C.1. Interview guide for the follow-up interviews (English and French versions).

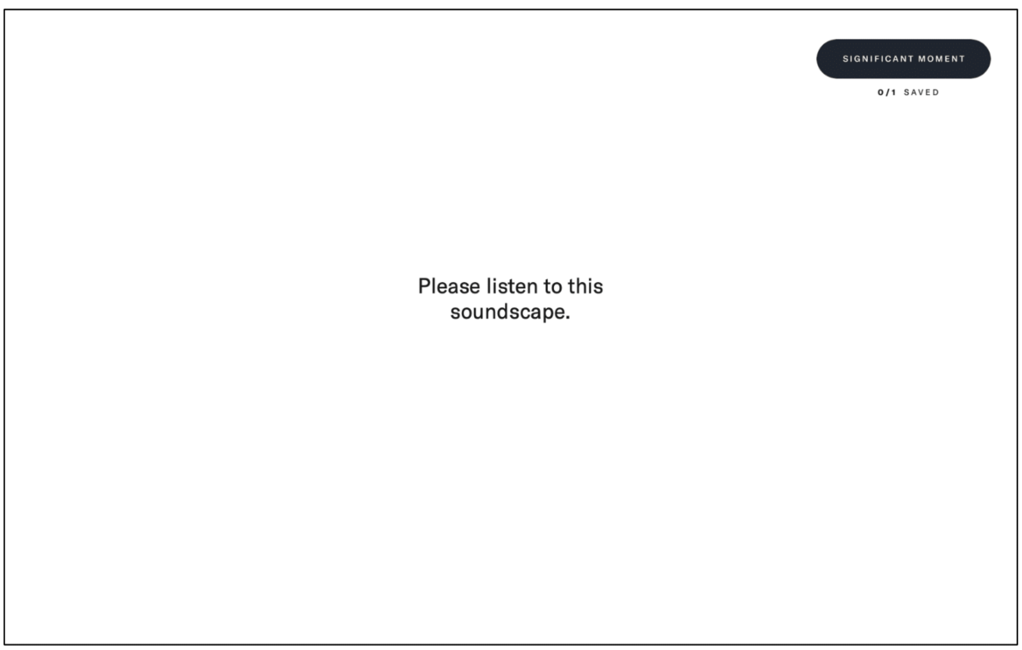
Instructions for the experiment

You will listen to different soundscapes which you will evaluate on an interface. These soundscapes contain sounds recorded in the Parc des Madelinots, and in some cases added sounds.

During your listening sessions, you will hear 3-minute soundscapes, each of them representing the same period that can, in reality, span several hours. These soundscapes will let you recall the same moment over and over again, with more or less pronounced sound variations.

Try as much as possible to listen to each soundscape as if you were hearing it for the first time.

While listening to a soundscape, you will have the option of clicking on a button in the top right-hand corner to indicate significant moments that struck you for one reason or another (see image below). You will listen to these moments again in the presence of the experimenter after the experiment to explain your choice. Please use this button sparingly: **you can only record one significant moment per soundscape**, with the option of replacing your choice if you change your mind during the soundscape.



1/2

Figure C.4. Instruction sheet given to participants before the experiment (page 1/2).

At the same time, you will evaluate this soundscape using scales that will be displayed on the screen in addition to the "Significant Moment" button after a brief moment, using your mouse (image below). **All scales must be used during the listening, even if you return the cursor to its initial position.** An alert will be displayed if you have not used all scales, indicating which scales have not been used. Please note that the values you enter on the scales refer to the entire three-minute soundscape in question and should therefore reflect your overall assessment of this listening as only the final position of the sliders will be considered. You can modify your ratings until the end of the listening session. Alerts will let you know when the listening is about to end at 30 seconds, 20 seconds and 10 seconds to the end.

Take the time to read each scale during the training you'll be doing with the experimenter and **take careful note of what is written at the top as well as at the bottom of the scales** for those on the right.

2/2

Figure C.5. Instruction sheet given to participants before the experiment (page 2/2).