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(Re)creating architecture through sound: Sound as a means of addressing sonic memories of the besieged Sarajevo

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Abstract
This study investigates the intersection of sound, architecture, and memory to address the auditory trauma and spatial disorientation caused by the Siege of Sarajevo (1992–1996). Positioning sound as both an evocative medium and a reconstructive tool, the research examines its capacity to convey collective memory, foster resilience, and support psychological recovery. Grounded in Bernhard Leitner's Sound Theory and the principles of aural architecture, the study employs a "research-to-create" methodology, combining survivor narratives with psychoacoustic design to produce two experimental sound installations.
The first installation, Symphony of the Siege, reconstructs the wartime sonic landscape of Sarajevo through electro-acoustic composition, guiding the listener through four spatial scales: urban expanse, street density, sheltered interiors, and intimate domesticity. The second installation, Peace, functions as a therapeutic sound composition, offering a contemplative transition from the visceral intensity of the first, encouraging emotional closure and spatial reflection.
Together, these installations not only replicate the acoustic and architectural conditions of conflict but also propose sound as a transformative architectural element—capable of reshaping spatial perception, mediating trauma, and reconstructing memory. The study advances the discourse on trauma-informed architecture by introducing sound as a critical material in the design of empathetic, multisensory environments. By bridging architecture, psychoacoustics, and trauma studies, this work offers a new framework for post-conflict spatial practices that foreground emotional restoration and collective remembrance.

Keywords
Aural architecture, Immersive soundscapes, Multisensory design, Sonic memory, Trauma-informed architecture.

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1. Introduction

This paper presents research undertaken within the framework of the Creative Europe Large Scale Cooperation Project, titled B-*AIR Infinity Radio*[1]. The project brought together a consortium of nine partner organizations from seven European nations, fostering a multidisciplinary collaboration that integrated scientific inquiry with artistic methodologies. The project investigated the impact of sound stimuli on cognitive and emotional responses, with a particular focus on vulnerable individuals and communities. By interweaving empirical research and creative production, the initiative sought to elucidate the role of sound in shaping human experiences across diverse contexts and environments. At the core of this endeavor was the synergy between artists and an interdisciplinary cohort of international experts, including scholars and practitioners from developmental psychology, neurophysiology, psychoacoustics, music therapy, and architecture. The project's collaborative network further extended to include national broadcasters, non-governmental organizations, research institutions, and universities, each contributing specialized expertise. This diverse partnership enriched the research process and informed the development of innovative, sound-based strategies to support vulnerable populations effectively. Our institution, International Burch University, within the framework of the B-AIR was responsible for the work package entitled '*Sound Lifeline*'. It focuses on the research concentrated on the interplay between sound, space, architecture, and memory, with a particular emphasis on the Siege of Sarajevo (1992–1996). Initially conceived as a conventional urban study aimed at assessing sound pollution in critical areas of Sarajevo, the project sought to propose architectural interventions and policy recommendations to mitigate the identified issues. However, early assessments and the identification of key areas of concern prompted a re-evaluation of the research's scope and objectives.

A comprehensive literature review, informal engagements with local residents, and an in-depth exploration of Sarajevo's sociocultural context revealed that our initial conceptualization of sound pollution was insufficient. The findings underscored the necessity of examining sound pollution not merely as an environmental or urban challenge but as a phenomenon intrinsically linked to the auditory trauma shaped by the city's recent wartime history. This realization necessitated a methodological pivot, moving beyond the physical and acoustic dimensions of sound to explore its aural and phenomenological characteristics. Sound emerged not only as an environmental factor but also as a crucial agent in shaping spatial and experiential realities. Consequently, the project adopted a multidisciplinary approach, integrating insights from sonic studies, trauma studies, and architectural theory to better comprehend the intricate relationship between sound, trauma, and urban space. This shift enabled a more nuanced and holistic understanding of how sound functions as both a source of distress and a potential medium for recovery in the context of Sarajevo's post-conflict urban landscape. The project's focus on Sarajevo arose not only from its historical significance as a site of prolonged urban conflict but also from the shared conviction among the team that revisiting its unique auditory and spatial experiences could provide insights applicable to other post-conflict urban settings. The author, trained in architecture with a focus on spatial memory, brought a particular interest in how sound interacts with physical environments to evoke collective and individual memories of place and trauma. Other team members contributed expertise from artistic aspects, as well as music therapy, ensuring the project's approach was both rigorous and interdisciplinary.

To ensure that the project was grounded in authentic experiences and reliable data, witness interviews emerged as a critical methodological pillar. These testimonies provided deep insights into how sound shaped both the mundane and extraordinary realities of life during the conflict, un-

covering its significant psychological and spatial implications. As a result, the '*Sound Lifeline*' project's methodology was restructured around a "research-to-create" framework, a process elaborated further in this paper. This approach integrated qualitative narrative interviews with thematic analysis, capturing the sonic memories of survivors of Sarajevo's siege, which were then transformed into evocative soundscapes, designed to reflect the emotional and architectural essence of wartime endurance and post-war recovery. Through this innovative methodology, the project aimed to examine how present-day collective sonic experiences are shaped by individual memories of conflict and to investigate the broader role of sound in urban and architectural contexts. Additionally, the research sought to explore sound as a potential medium for addressing sonic trauma, providing a deeper understanding of its implications for both personal and communal resilience.

The paper argues that sound, as an intrinsic architectural element, possesses the transformative potential to redefine spatial perception and emotional resonance in post-conflict environments. By employing soundscapes to reconstruct the auditory memory of Sarajevo's siege, this study demonstrates how architecture, enriched through aural dimensions, can address collective trauma and foster psychological healing. The integration of technological sound art, informed by Leitner's Sound Theory, underscores the viability of sound as a medium for creating empathetic, trauma-informed spaces, thus advancing the architectural discipline toward a multisensory and therapeutic paradigm.

1.1. Conceptual Framework

In the domain of sonic studies, a critical distinction must be made between acoustic architecture and aural architecture. The former pertains to the quantifiable, physical characteristics of sound within architectural spaces, encompassing metrics such as reverberation time, sound absorption coefficients, and the spatial propagation of sound waves (Blesser & Salter, 2007). Conversely, aural architecture engages with the intangible dimensions of sound, examining its capacity to influence emotional states, behavioral responses, and physical sensations within an environment (Ouzounian, 2021). This study is firmly anchored in the aural perspective, emphasizing the profound impact of sound on individual and collective memory. It asserts that sensory experiences transcend the materiality of architectural spaces, extending to their psychological resonance and emotional significance.

The integration of sound into architectural analysis is indispensable for comprehending how spaces evoke and transform emotional states, particularly in contexts marked by conflict and its aftermath. This research leverages such insights to investigate the soundscapes experienced during the siege of Sarajevo, which functioned not merely as passive auditory backdrops but as active, transformative forces that shaped the lived experiences of the city's inhabitants. Drawing upon narrative interviews with fifteen survivors, the project interrogates the interplay between sound and architectural space during wartime, advancing a nuanced understanding of how auditory stimuli influence urban adaptation and perception amidst crisis.

By positioning sound as an operative element within architecture, the study transcends traditional emphases on visual and spatial aesthetics to demonstrate how sonic phenomena reshape architectural experience and functionality. The sound installations developed through this project embody this principle, highlighting architecture's capacity to serve as a medium for emotional and psychological engagement when integrated with aural dimensions. This methodological approach draws heavily on the pioneering work of Bernhard Leitner, whose sound installations revolutionized the conceptualization of sound as a primary material for spatial creation. Leitner's Soundcube installations, conceived in the 1960s, exemplify how sound redefines spatial boundaries and perception, offering foundational insights into the field of aural architecture and its interaction

with the built environment (Martinho, 2019; Ouzounian, 2021).

This conceptual framework informed the project's efforts to reconstruct the layered spatial and emotional landscapes of war-torn Sarajevo, utilizing sound to evoke collective memory, trauma, and resilience. The "*research-to-create*" methodology culminated in the development of two artistic modules: an electro-acoustic sound installation by Haris Sahačić titled 'Symphony of the Siege' and a complementary sound recording by Mirsada Zećo named 'Peace'. These installations were meticulously designed to reconstruct and engage with the sonic memories of war, particularly the auditory experiences that deeply resonated with survivors of the Sarajevo siege. The overarching aim was to establish a platform for addressing entrenched sonic traumas, fostering empathy among participants, and exploring pathways for healing through the integration of sound and spatial experiences (Blesser & Salter, 2007; Ouzounian, 2021).

The *'Symphony of the Siege'* installation translated emotional and physical wartime memories into an immersive auditory narrative, inviting visitors to engage with the layered trauma and resilience of siege survivors. By employing sound technology as a medium, the installation underscored the potential of sound to function as a critical element in architectural spaces, fostering collective memory and psychological well-being. Complementing this, 'Peace' provided a restorative counterpart, transitioning listeners from the evocative intensity of *'Symphony of the Siege'* to a serene, introspective auditory environment. Together, these installations encapsulated the duality of conflict and recovery, serving as both evocative and therapeutic interventions.

Showcased as part of an exhibition by the same title *'Sound Lifeline'*, which debuted at the Historical Museum of Bosnia and Herzegovina (see Figures 1 and 2) in May 2023 and subsequently at the Research Centre of the Slovenian Academy of Sciences and Arts in June 2023, these artistic modules highlighted the project's broader implications for the fields of architecture, art, and trauma recovery. Additionally supported by the MESS Festival in Sarajevo and Global Specificity Event in Ljubljana by Radio Television Slovenia, the exhibitions provoked discourse on the potential of sound and space as tools for post-conflict healing and remembrance. These installations exemplified the capacity of sound to transform architectural spaces into vessels of empathy, memory, and emotional restoration, advancing a paradigm wherein aural elements become integral to architectural praxis in contexts of historical and emotional complexity.

1.2. Leitner's sound theory and *Soundcube* art installations

Bernhard Leitner advanced the radical proposition that sound could function as a primary material in the construction

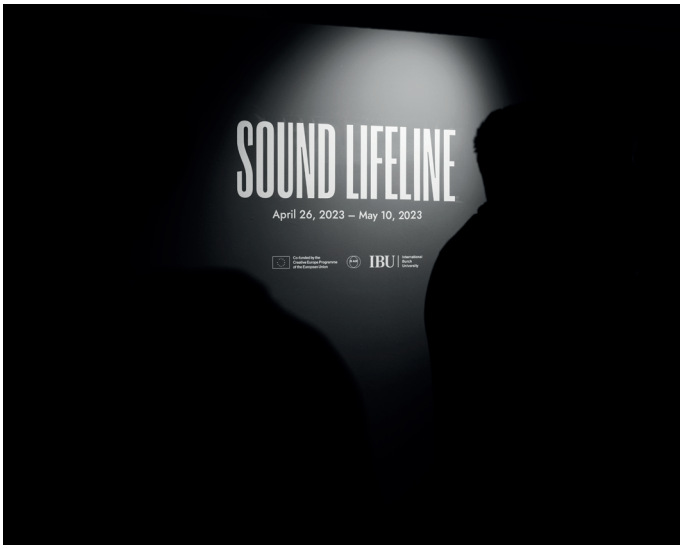

Figure 1. *Photos from the 'Sound Lifeline" exhibition at the Historical Museum of Bosnia and Herzegovina May 2023.*

Figure 2. *Photos from the 'Sound Lifeline" exhibition at the Historical Museum of Bosnia and Herzegovina May 2023.*

of spatial experiences, fundamentally redefining the conceptual boundaries of acoustic phenomena within architectural contexts. Trained as an architect but primarily operating as an artist, Leitner sought to transcend traditional visual paradigms of spatial engagement by embracing the auditory realm. His theory of corporeal hearing posits that the human body serves as a holistic receptor for sound, perceiving it not merely through the ears but through the entirety of one's physical being (Leitner, 1998). This theoretical framework underpins his body of work, wherein he seamlessly integrates sound into architectural frameworks, creating spatial experiences in which sound becomes the defining and structural element (Leitner, 1971).

Leitner's installations, often described as sound-space objects, engage the body in a multisensory dialogue that challenges conventional visual or externally imposed spatial appraisals. These works are characterized by their dynamism and mutability, crafting spaces that oscillate, ascend, and descend, thus embodying diverse spatial dimensions and temporal evolutions. Crucially, Leitner envisioned sound not as an auxiliary feature but as a foundational component in designing immersive and distinctive. His contributions have profoundly reshaped the understanding of the interplay between sound and space, continuing to influence contemporary practices in both sound art and architectural design (Siebein, 2009).

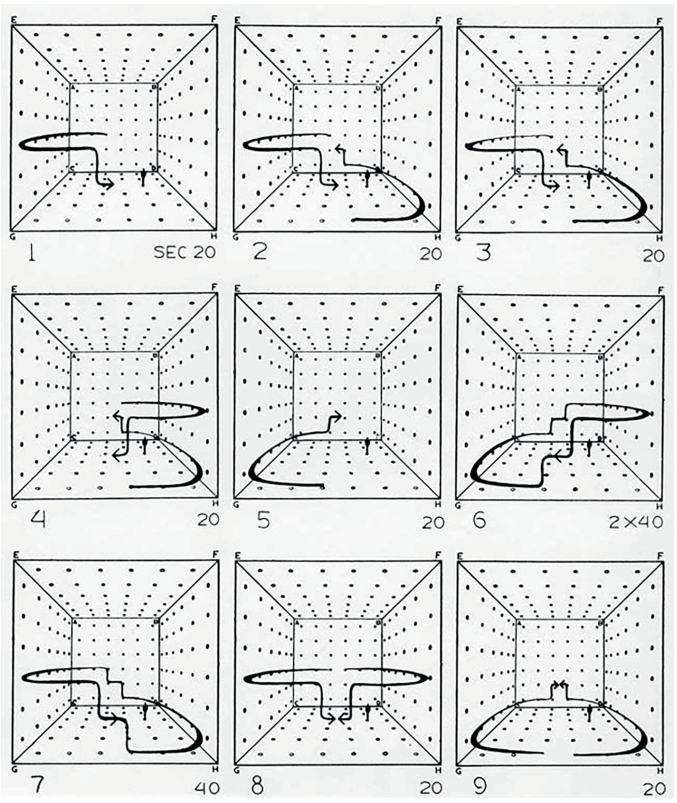

Figure 3. *SOUNDCUBE by Bernard Leitner is envisioned as a counter-directional cylindrical space. Sound spaces are in substance spaces of time. Their form is composed of sequences of part-spaces in time. Space is created, and evolves, only to end again.*

One of Leitner's most seminal creations—and a key influence on the research presented in this paper—is the Soundcube, conceptualized in the 1960s. More than a mere installation, the Soundcube functions as an instrument for generating spatial environments entirely through sound (Leitner, 1971). Comprising a grid of loudspeakers arranged across the six walls of a cube, the structure is visually neutral, devoid of specific visual or spatial symbolism (Figure 3), and adaptable in its dimensions (Martinho, 2019). This neutrality allows for the creation of an infinite variety of spatial sensations, with the configuration of its interior defined solely by the interplay of sound movements. The six inner walls are lined with 384 evenly distributed loudspeakers, and the programming of sound movements across this array is meticulously orchestrated using twelve notation sheets, detailing the technical specifications for sound distribution and its progression through the loudspeakers (Siebein, 2009).

The Soundcube served as a laboratory for Leitner's investigations into the nature and definition of space, as well as the intricate relationship between sound motion and its audio-physical experience (Leitner, 1998). It provided a platform for examining how sound defines spatial boundaries and manipulates human perception of movement within those boundaries. Leitner further explored the determinants of sound architecture, including the interdependence of space and time, and the profound neurological effects of acoustic phenomena. As he observed in his seminal writings:

> "…among the already facts the following seems to be of basic significance for sound architecture: neurophysiological experiments

> have proven that acoustics are the critical lever of changing the level of brain activity. Specific musical elements produce specific unconscious nervous reactions" (Leitner, 1971, p. 18).

This interplay between acoustics and neurophysiology resonates deeply with the research discussed in this paper. Leitner's assertion that sound architecture can modulate brain activity and evoke unconscious responses underscores the potential of sound to function as a transformative spatial element. In this framework, the boundaries of space are no longer confined to physical materials but are instead dynamically generated through sound (Blesser & Salter, 2007). Leitner's innovative approach has thus become a cornerstone for understanding how auditory environments can redefine spatial perception, offering an enduring legacy that continues to inform experimental practices in both architecture and sound art.

2. Project methodology

2.1. Interviews

The selection and interview process for the 'Sound Lifeline' project adhered to anthropological methodologies that prioritize narrative depth and contextual richness to understand lived experiences. Participant selection followed the principle of purposive sampling, a qualitative research method that identifies individuals with unique and relevant experiences aligning with the study's objectives (Bryman, 2016). For this study, participants comprised a diverse group of individuals who had survived the siege of Sarajevo and subsequently became pivotal figures in the domains of memory, culture, and public history—such as artists, curators, and historians. These participants not only experienced the siege firsthand but also played active roles in preserving and communicating Sarajevo's collective memory, making them ideal for articulating nuanced sonic narratives from the wartime period.

Anthropologically, these "memory-bearers" were selected because their reflexive awareness of their experiences enabled them to articulate the complex interplay of sound and memory with greater precision (Das, 2007). Veena Das emphasizes that the act of testimony, particularly in trauma narratives, serves both personal and communal purposes. It is a dual process of processing trauma and preserving collective memory. As Das notes, the act of empathetic listening transforms testimony from a mere historical account into a therapeutic exchange, fostering a shared journey between the narrator and the listener (Das, 2001).

The interview process employed a semi-structured narrative approach, allowing participants to guide the conversation toward the most significant aspects of their memories (Chase, 2012). This method, widely used in anthropological research, facilitates a natural recounting of experiences, ensuring depth and authenticity in the narratives. Importantly, the interview structure expanded beyond overtly traumatic sounds, such as ballistic noise, to include quieter, everyday sounds—like footsteps, whispers, and silences—that were equally integral to the siege experience. This aligns with Geertz's concept of "thick description," which captures the richness and complexity of lived realities (Geertz, 1973).

One of the most compelling themes that emerged from the interviews was the role of silence as both a sensory and psychological marker in Sarajevo's wartime soundscape. Drawing on sound studies literature, the project framed silence not as a mere absence of sound but as an active presence, often heightening anticipation and fear (Ben-Ze'ev, Ginio, & Winter, 2010). As Barry Tru-

Figure 4. *Studio Recording Environment of the Interviews. Photo by the IBU research team.*

ax argues, silence can oscillate between comfort and tension, a duality particularly significant in conflict zones where sudden silences often signal impending danger (Truax, 2001).

This methodologically robust process enabled the 'Sound Lifeline' project to construct a detailed, human-centered representation of Sarajevo's wartime soundscape, enriching our understanding of how communities experience and process trauma through auditory phenomena. The interview process itself was deeply engaging, both technically and emotionally. The author, supported by a team of six to eight crew members, conducted interviews that were audio- and video-recorded to ensure comprehensive documentation as seen on Figure 4. The interviews took place in carefully prepared settings that balanced professional visibility with intimacy, providing participants a safe space to recount their experiences. Each session, lasting one to two hours, revealed a profound interplay of resilience, humor, and ingenuity amid accounts of fear and loss, underscoring the adaptability of the human spirit.

The process also carried a heavy emotional weight. For instance, one witness recounted the devastating memory of a brother's death by sniper fire, a moment that moved the entire crew to tears. The interviewer offered the participant the option to omit this segment, respecting the potential distress it could cause. However, the witness chose to proceed, stating that sharing the story was a way to honor his brother's memory. This decision illuminated the profound emotional complexity and personal significance of these narratives. Several participants later expressed gratitude for the opportunity to share their stories, affirming the value of the interview process in fostering reflection and collective acknowledgment of shared experiences. These testimonials not only informed the subsequent phases of the project but also reinforced the role of the interviews as an integral element of therapeutic engagement. This aligns with Das's assertion that testimony, when met with attentive and empathetic listening, transcends its historical function to become an active, recuperative process for trauma survivors (Das, 2007).

The interviews were transcribed and analyzed to capture the auditory dimensions of wartime experiences. As Das emphasizes, the act of recounting traumatic events can reconstruct the unspeakable, integrating fragmented memories into coherent narratives (Das, 2007). These interviews provided the foundational material for recreating the auditory environment of the siege in contemporary sound installations, as discussed in subsequent sections. Through this dual process of testimony and creative production, the 'Sound Lifeline' project illuminated the enduring significance of sonic memory as a lens for understanding and addressing trauma.

2.2. Interview analysis

To understand the patterns within the wartime soundscape, the project employed a systematic transcription and thematic analysis of interviews, drawing on contemporary war theory (Daughtry, 2015; Velasco-Pufleau, 2021; Goodman, 2012) and the relationships between sound, music, and violence (Atlani-Duault, 2020; Gilman, 2016; Grant & Papaeti, 2013; Rice, 2016; Nuxoll, 2015; Ouzounian, 2021). Although individual testimonials reflected unique experiences, recurring sonic patterns emerged, underscoring shared dimensions of wartime auditory phenomena.

Thematic analysis was employed to identify and examine these recurring patterns. Through axial coding, relationships between emergent themes were systematically explored, revealing the powerful capacity of sound to evoke memory, emotion, and reflection on conflict. These themes offered critical insights into how sound influences human experiences and adaptations in extreme circumstances. This methodological approach aligns with narrative inquiry, which, as Chase (2007) observes, provides a coherent framework for interpreting stories and cultural phenomena that may evade other research methods. Four primary themes emerged as central to understanding the sonic memories of those who en-

dured the siege of Sarajevo: (1) Sound as Survival, (2) Silence as a Weapon, (3) Sound as Memory and Orientation, and (4) Sound as Resistance and Community Resilience. These themes later informed the conceptual framework for artistic outputs associated with the project but are analyzed here purely for their contribution to understanding the wartime soundscape.

(1) Sound as Survival: One of the most prominent themes was the role of sound as a survival mechanism. Participants frequently described how specific sounds—such as the distinct pitch of incoming artillery or the cadence of footsteps—became tactical signals for immediate action. These sounds served as auditory markers, enabling residents to anticipate danger and respond appropriately. This theme illustrates the heightened sensitivity to sound that becomes vital in conflict zones, reflecting an adaptation to an environment dominated by unpredictable threats.

(2) Silence as a Weapon: Silence emerged as an equally significant theme, carrying an ominous psychological weight. Unlike audible trauma, silence during the siege often signaled impending danger, amplifying anxiety and uncertainty. Participants described silence as both a sensory and psychological marker, intensifying the anticipation of violence. This aligns with findings by Ben-Ze'ev et al. (2010), who argue that silence in conflict settings functions as a psychological weapon. Truax (2001) similarly highlights the dual nature of silence as both oppressive and protective, underscoring its complex role in shaping emotional and psychological responses during war.

(3) Sound as Memory and New Orientation in Space: Another key theme was the use of sound for spatial orientation and memory. In a city where visual barriers were often used for hiding the view from the snipers on the hills, residents relied heavily on auditory cues to navigate their surroundings. Footsteps, echoing voices, and the hum of machinery became crucial in maintaining spatial awareness. This theme aligns with Das's concept of sensory "anchors," which stabilize individuals during periods of dislocation (Das, 2001). The auditory environment thus functioned as a critical framework for preserving a sense of place and memory amidst the chaos of conflict.

(4) Sound as Resistance and Community Resilience: The final theme highlighted the role of sound in fostering resistance and resilience. Participants described communal sounds, such as singing, drumming, concerts, theater plays and radio broadcasts, as powerful symbols of defiance and solidarity. These auditory practices reclaimed sonic space from the oppressive sounds of war, fostering agency and cultural continuity. Velasco-Pufleau (2020) underscores the significance of communal soundscapes as tools for resistance, reinforcing their capacity to counteract the traumatic soundscape of conflict.

These themes form the foundation of the project's analysis, offering a comprehensive understanding of the sonic dimensions of war as experienced by Sarajevo's residents. Each theme provides a lens through which to examine the profound impact of sound on memory, behavior, and resilience in conflict zones. The insights drawn from this analysis later informed the conceptual development of artistic productions, which sought to translate these themes into tangible explorations of sound, space, and memory. However, the analytical framework presented here focuses solely on the thematic contributions to understanding the complex interplay between sound and human experience during the siege.

3. Addressing sonic war memories through artistic intervention: Research to create – science to art approach

The electro-acoustic composition, the project's primary artistic module, serves as an architectural and auditory reconstruction of Sarajevo's wartime soundscape, directly influenced by survivor interviews. By using sound as a fundamental material, this work creates an immersive experience that not only conveys the auditory realities of conflict but also explores how sound shapes spatial perception and memory. The composition guides listeners through

distinct architectural scales—from the vastness of the urban environment to the intimacy of personal spaces—mirroring the layered experiences of movement, confinement, and survival during the siege. This auditory architecture invites participants to engage deeply with the materiality of sound as it defines and redefines spatial boundaries, effectively transforming sound into an architectural element that evokes both physical spaces and emotional responses.

Complementing the electro-acoustic composition is the sound composition, a therapeutic piece that provides a counterbalance to the intensity of the primary module. While the electro-acoustic work delves into the traumatic and visceral dimensions of wartime soundscapes, the sound composition adopts a restorative architectural approach. It uses sound to "build" a calming, reflective environment, offering listeners a psychological and emotional space for recovery. Through carefully crafted frequencies and gradual tonal shifts, the sound composition transitions from the discordant chaos of trauma to harmonic resolution, symbolically mirroring the process of spatial and emotional healing. This work highlights how sound, as an architectural tool, can be used not only to reconstruct experiences of conflict but also to create spaces of resilience and introspection.

Together, these two modules illustrate an architectural narrative that bridges the visceral with the therapeutic. The electro-acoustic composition confronts listeners with the realities of spatial disruption and auditory violence, reshaping their understanding of space and memory through sound. The sound composition then uses architectural principles of spatial clarity and sensory modulation to provide a therapeutic "cleansing," offering a restorative counterpoint that underscores the potential of sound to reconfigure emotional and spatial realities. This duality demonstrates how sound can be employed architecturally—not only to evoke and reconstruct physical and psychological spaces but also to create environments conducive to healing and reflection.

3.1. Gallery and installation spatial configuration

The 'Sound Lifeline' installations were held in a temporary gallery space at the Historical Museum of Bosnia and Herzegovina, an institution with a distinguished role in preserving Sarajevo's cultural memory, particularly concerning themes of the siege. This venue's national significance and thematic alignment provided an ideal context for the project, positioning the installation within a space committed to engaging with the city's wartime experiences.

The gallery room, measuring 12 meters by 6.5 meters, presented distinct spatial and acoustic challenges that shaped the technical design and layout of the installation. The elongated rectangular shape necessitated careful planning of speaker placement, acoustic treatments, and seating arrangements to achieve an immersive auditory experience while mitigating issues such as echo and sound reverberation. To address these constraints, the project team implemented several architectural and acoustic interventions. A temporary wall was installed three meters from the rear end of the gallery, effectively converting this section into a technical space while creating a central 6-meter radius for the placement of six speakers (see Figure 5). This configuration optimized the spatial dynamics for sound distribution and audience immersion. Additionally, the existing antechamber at the gallery entrance served as a natural sound diffuser, softening the auditory transition into the main installation space. Openings in the gallery walls were treated with heavy cloth curtains to enhance sound absorption and eliminate unwanted reverberation. A carpeted floor further contributed to sound dampening, reinforcing the clarity and precision of the sound environment.

To enhance the sensory focus on sound, lighting was intentionally minimal. Two narrow-source light pointed towards the floor were positioned strategically: one at the entrance and the other at the center of the installation, providing just enough illumination for visitors to navigate to their seats. This subdued lighting design dulled visual

stimuli, heightening auditory perception and aligning with the installation's intent to immerse visitors fully in the soundscape. Together, these thoughtful spatial and acoustic modifications transformed the gallery into a controlled and evocative auditory environment, tailored to deliver a profound sensory and architectural experience.

Both installations used the same gallery and set up and the six speakers used were Adam 5V audio monitors, arranged in a circular configuration, to optimize the multi-directional sound distribution. Although the six-speaker setup was selected partly due to equipment availability and budget constraints, it enabled a high-quality, immersive listening experience that met the project's objectives. The circular arrangement was particularly impactful in the context of psychoacoustics, as it allowed visitors to position themselves centrally, fully surrounded by sound sources from all direction (see Figure 6). Each speaker was calibrated to support the spatial dynamics of the soundscape, delivering targeted acoustic interferences that reflected specific sonic movements, such as the passing of an aircraft overhead or the crackling of a candle.

The directionality of the speakers and the intentional overlapping of soundwaves were fundamental to recreating the layered auditory complexity of Sarajevo's wartime and post-conflict in both the 'Symphony of the Siege' and 'Peace' installations. In 'Symphony of the Siege', for instance, sounds such as an airplane flyover were designed to pan seamlessly between soundscape speakers, creating a vivid sense of movement across the gallery space. Similarly, the sharp crack of distant gunfire contrasted with the intimate rustling of fabric or a child's piano practice, diffused across multiple speakers with slight variations. This technique evoked the coexistence of proximity and distance, blending the stark immediacy of conflict with fragmented, distant memories. In 'Peace', by contrast, the same principles were adapted to foster calm and introspection, with tonal transitions moving fluidly around the listener, creating a gradual descent from heightened tension to serenity. More about the composition of the two installations is elaborated in the following sections of the paper.

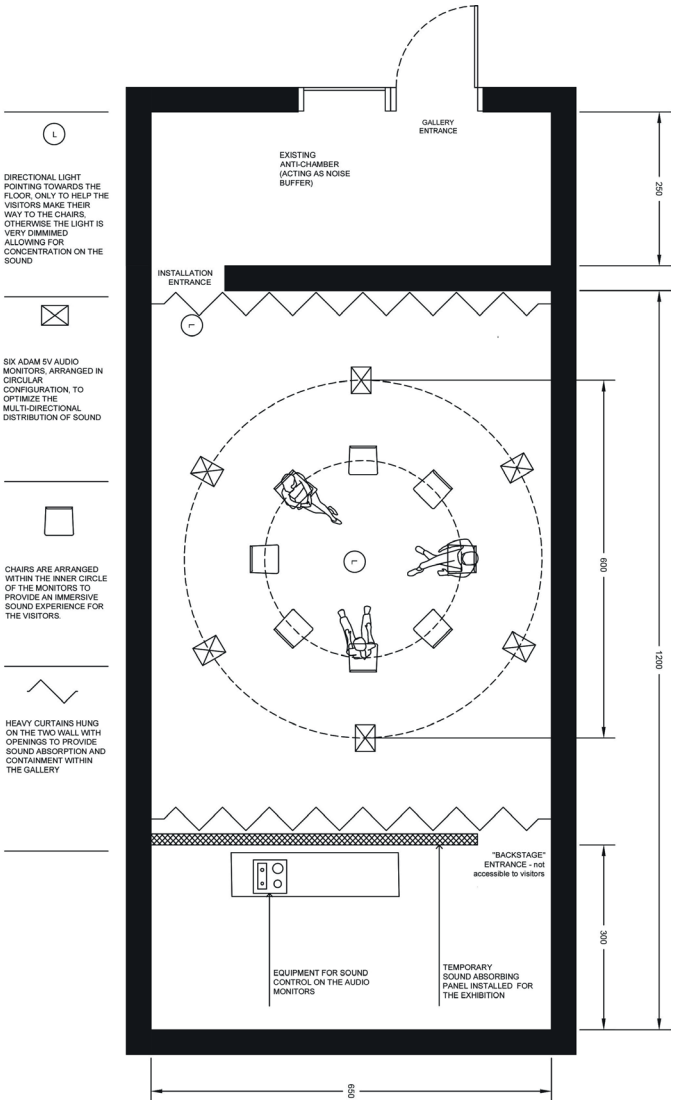

Figure 5. *Floor Plan of the gallery set-up at the temporary exhibition hall of the Historical Museum of BH, for the two artistic installations. Drawing by Lejla Odobašič Novo.*

Figure 6. *Photo of the installation at the exhibition 'Symphony of the Siege' at the Historical Museum of BH May 2023. The lights have been brightened for better visibility of the gallery setup in the photo. Photo by Lejla Odobašič Novo.*

Using psychoacoustic principles, the team meticulously orchestrated sound overlaps, phase adjustments, and directional cues to create an immersive and enveloping auditory experience. In 'Symphony of the Siege', this approach replicated the unpredictable and disorienting auditory environment of wartime Sarajevo, with sounds shifting dynamically across the circular array of six Adam 5V monitors similar to Leitner's approach in *Soudcubes* (Leitner, 1971). The controlled acoustic interactions mimicked the layered and fragmented soundscape of the siege, while subtle manipulations in volume and frequency further enhanced the emotional resonance of each sound. In 'Peace', these techniques were employed with a therapeutic intent: spatial transitions were smooth and deliberate, fostering a sense of safety and containment. Gradual phase adjustments and harmonic overlaps created an evolving sound environment, allowing listeners to journey through the emotional tension of 'Symphony of the Siege' into a state of reflection and recovery (Redmond, 2013; Truax, 2001).

While the gallery's size and available equipment introduced some limitations, the installations' design effectively conveyed the project's core themes. The strategic placement of speakers in a circular configuration, coupled with careful acoustic treatment, transformed the room into an evocative auditory space that authentically reconstructed Sarajevo's wartime and post-conflict soundscapes. In 'Symphony of the Siege', the arrangement immersed participants in the layered realities of conflict, while in 'Peace', it facilitated emotional closure and introspection. The thematic alignment with the Historical Museum of BH further reinforced the installations' conceptual foundations, creating a space that engaged visitors both sensorially and emotionally, bridging the past and the present through sound (Ouzounian, 2021; Augoyard & Torgue, 2005).

4. Electro-acoustic composition 'symphony of the siege': Architectural re-creation through sound

The architectural principles underlying the composition are supported by key works in aural architecture. Spaces Speak, Are You Listening? by Blesser and Salter (2007) and Sonic Experience: A Guide to Everyday Sounds by Augoyard and Torgue (2005) provide theoretical frameworks demonstrating how sound shapes space and defines spatial experience. These concepts validate the project's goal to recreate the experience of Sarajevo's architecture through sound, emphasizing that aural elements can construct a sense of place and memory comparable to physical architecture. By invoking these architectural theories, the 'Symphony of the Siege' composition grounds itself in the broader field of aural architecture, reinforcing the claim that soundscapes can serve as architectural tools that reconstruct spatial and emotional experiences.

Traditional architecture uses physical materials—walls, floors, ceilings—to create space and define human experience. In contrast, the 'Symphony of the Siege' electro-acoustic composition leverages sound as a spatial tool, reshaping how we perceive and interact with environments by invoking the spatial experiences and atmospheres associated with architecture. Here, "recreating architecture" does not imply replicating physical structures but, rather, evoking the sense of spatial scale and atmosphere that these structures provide. Through sound, we introduce an alternative mode of spatial experience, using auditory cues to evoke the distinct characteristics of urban, street, interior, and intimate scales. This approach blurs the line between sound and physical architecture, engaging listeners in an experience of space that exists in perceptual, rather than tangible, terms.

The Sound Lifeline project's 'Symphony of the Siege' electro-acoustic composition is structured to capture and convey the layered experiences of the Sarajevo siege through carefully arranged soundscapes. This structure is directly derived from the thematic analysis of interviews conducted with survivors, and each act within the composition is a meticulous recreation of a specific memory shared by these interviewees. By translating their memories into a sound-based narra-

tive, 'Symphony of the Siege' immerses the listener in the emotional and spatial dynamics of the siege, providing an auditory path through personal and collective recollections of conflict.

4.1. Sound composition as a representation of architectural scale

The 'Symphony of the Siege' electroacoustic composition is composed as a symphony and unfolds across four distinct acts. The journey through the four acts also represents four distinct architectural scales: the urban landscape, the streets, interior spaces, and the intimate, personal space of individual experience. This structure embodies the experience of navigating physical environments during the Sarajevo siege and aims to recreate that spatial experience through sound. Each scale within the composition uses sound to replicate how individuals perceive and move through these spaces, applying architectural principles to evoke a sense of place through auditory cues. The composition's progression reflects how architecture shapes human experience and emotional response, creating an immersive soundscape that guides listeners through the acoustic architecture of wartime Sarajevo.

The composition's structure utilizes sound to emulate spatial transitions from urban openness to private intimacy, aligning with concepts in aural architecture. Through this design, sound acts as more than an aesthetic element; it becomes a medium for spatial experience. By layering sounds to reflect distinct architectural environments, the composition provides a form of "constructed" space that listeners perceive as tangible, despite the lack of physical structures. This use of sound for place-making aligns with Blesser and Salter's exploration of "aural architecture," where sound defines space and shapes experience as effectively as built walls and enclosures (Blesser & Salter, 2007).

4.1.1. Act 1: Urban scale (4/4 time signature)

- Objective: Establishes the broad, distant sounds associated with the siege.
- Opening Sound: A warplane breaking the sound barrier, marking the beginning of the siege.
- Gunshot Sequence: Begins with 233 gunshots at 14,400 meters distance. Over time, the distance narrows to 8,900 meters (144 gunshots in the 47th second) and to 5,500 meters (89 gunshots in the 94th second), symbolizing the increasing encroachment of conflict on the city.
- Spatial Reflection: This narrowing of distance and intensifying sound volume mimics the encroaching conflict, moving from the city's edges toward the listener.

The first act captures the sense of an expansive urban landscape (see Figure 7), with distant, low-frequency sounds like the rumble of planes and far-off gunfire symbolizing the periphery of Sarajevo. By simulating the open vastness of the city under siege, this soundscape reflects the architectural experience of observing a city from afar, where wide-open space creates a particular emotional resonance. Sound here is crafted to mimic spatial distance and scale, which, as Blesser and Salter note in *Spaces Speak, Are You Listening?*, is a core aspect of how aural architecture informs an individu-

Figure 7. *Sarajevo Panorama during the Siege representing the urban scale. Photo by Paul Lowe used with permission.*

al's spatial perception and engagement with large environments (Blesser & Salter, 2007). The urban scale emphasizes "place-making" in architecture, giving listeners a sensation of spatial openness in relation to the city's physical contours.

4.1.2. Act 2: Street scale (3/4 time signature)

- Objective: Focuses on sounds experienced at the neighborhood or street level.
- Gunshot Sequence: 55 gunshots at 3,400 meters in the 140th second.
- Effect: Brings the listener closer to the conflict, placing them within a street-level view of the siege's unfolding dangers.

In the second act, the soundscape narrows to represent the street level, creating an auditory sense of confinement typical in urban corridors (see Figure 8). Here, sounds such as footsteps, voices, and nearby gunshots echo off virtual "building facades," designed to simulate how sound behaves in enclosed streets. This auditory enclosure reflects the architectural function of streets and alleys as spaces that constrain movement and amplify nearby sounds.

The modulation of reverberations and directional sound elements in this act mirrors the experience of moving through dense urban settings, where walls shape and contain sound in a way that heightens spatial awareness. This approach aligns with Augoyard and Torgue's concept of "spatialized sound" in *Sonic Experience: A Guide to Everyday Sounds*, where architectural structures create and confine sound environments that influence how individuals navigate space (Augoyard & Torgue, 2005).

Figure 8. *View of the Holiday Inn Hotel during the winter months of the siege representing street scale. The sign states "Danger Zone: Run or RIP". Photo by Paul Lowe used with permission.*

Figure 9. *Cloth curtains were placed in the streets of Sarajevo to protect the citizens from the view of the snipers representing inhabited scale space. Photo by Paul Lowe used with permission.*

4.1.3. Act 3: Inhabited space scale (2/4 time signature)

- Objective: Moves the listener to an indoor or building-specific environment.
- Gunshot Sequence: 13 gunshots at 800 meters in the 282nd second.
- Effect: This act shifts the experience inward, creating a sense of the siege affecting one's own immediate living space.

In the third act, the soundscape transitions to the indoor scale, where muted sounds convey the sense of being within walls and ceilings (see Figure 9). Low, resonant sounds, such as faint murmurs and mechanical hums, recreate the auditory insulation found in indoor spaces. This evokes an intimate scale of architectural experience associated with shelter and privacy, which were paramount for Sarajevo residents seeking refuge.

This stage incorporates psychoacoustic techniques to simulate how sound reverberates within enclosed spaces, using controlled echo and reverb to approximate the feeling of

physical boundaries. It reflects the "aural privacy" discussed in architectural acoustics, where sound isolation within a space contributes to a psychological sense of security and refuge (Blesser & Salter, 2007). The interior scale thus connects auditory perception to the protective function of architecture in times of crisis.

4.1.4. Act 4: Intimate scale (1/4 time signature)

- Objective: Conveys deeply personal, close experiences with loss and trauma.
- Single Gunshot: A single, significant shot at 100 meters, symbolizing a deeply personal loss, as it recalls the sniper killing of a witness's brother.
- Emotional Impact: This single shot, close and intimate, reflects the toll of war on individual lives, culminating in a space of extreme personal trauma.

The final act presents the most personal and intimate scale, where isolated, intense sounds—such as a single, close-range gunshot—symbolize deeply traumatic memories. By minimizing reverb and focusing sound directionality, the act creates a visceral, raw auditory experience, emulating the closeness of a personal space where private traumas unfold. This scale parallels the architectural intimacy of personal environments, spaces that are often the most emotionally significant and where memories are deeply embedded. Augoyard and Torgue emphasize that in spaces where sound lacks diffusion, listeners experience a heightened sense of intimacy and personal connection (Augoyard & Torgue, 2005). Here, sound becomes a metaphorical "wall" enclosing the listener, evoking the auditory experience of sheltering within small, protected spaces during conflict.

In using sound to convey the auditory characteristics of different architectural scales, the 'Symphony of the Siege' composition thus allows listeners to traverse the reconstructed spaces of wartime Sarajevo. Each act embodies an auditory approach to architecture, facilitating an immersive experience that mirrors how architecture influences perception and emotional response, thereby creating a dynamic sound-based architecture of memory and trauma.

4.2. Sound miniatures as sonic memories, rhythm as spatial configuration

In the 'Symphony of the Siege' installation, Haris Sahačić skillfully employed psychoacoustic principles to craft an auditory environment that transcended mere sound delivery, creating a deeply immersive and evocative experience that simulated the layered spatial and emotional realities of wartime Sarajevo. This approach leveraged sound as an architectural medium to reconstruct the auditory and psychological dimensions of the siege, drawing from survivor narratives and the thematic framework of *Sound as Survival*, *Silence as a Weapon*, *Sound as Memory and Orientation,* and *Sound as Resistance and Community Resilience*. These themes were interwoven into the structure of the sound miniatures and the overall composition, transforming individual memories into an auditory landscape that evoked spatial perception, movement, and visceral emotional responses.

4.2.1. Sound miniatures: Capturing the layered realities of war

Furthermore, as discussed earlier, the installation was composed of 44 individual sound miniatures and as can be seen in the score, each representing a month of the 44-month-long siege of Sarajevo. These miniatures formed an auditory chronicle of the conflict, with a tempo of 44 beats per minute symbolizing the slow and grinding passage of time during the siege. Each act in the installation represented a different urban scale—progressing from expansive urban landscapes to the intimate personal spaces of survival. Rather than relying solely on traditional components like reverb and echo, each miniature served as an independent narrative, capturing specific memories as recounted during interviews with survivors. For example, one miniature reconstructed the sound of hurried footsteps on a broken street, evoking the memory of one of the witnesses rushing to fetch water under sniper fire. Another miniature featured the distinct

clang of pots and pans, symbolizing the resilience of the citizens of Sarajevo who used every resource to cook in the face of scarcity and danger.

The rhythmic and spatial configuration of these miniatures further reinforced the immersive quality of the installation. Using a clockwise sound movement, gunshots and other auditory elements were projected from speakers in a circular configuration around the listener, with the sound shifting every 47 seconds. This movement mimicked the disorienting and immersive auditory environment of the siege, where danger could emerge from any direction. The composition also employed the Fibonacci sequence to organize the progression of sound intensity and proximity, symbolizing the exponential nature of conflict escalation. As the sequence progressed, sounds became increasingly layered and proximate, amplifying the psychological pressure associated with the siege. This rhythmic and spatial arrangement, rooted in Leitner's Sound Theory and *Soundcube* installations, challenged the physical boundaries of space by using sound as a tool to construct spatial and emotional confinement.

4.2.2. Psychoacoustic principles in action

Localization and spatial perception were foundational to the installation's design, directly reflecting *Sound as Memory and Orientation.* Through precise manipulation of interaural time differences (ITD) and interaural level differences (ILD), sound was perceived as emanating from specific directions, enabling participants to experience movement and spatial shifts. These auditory cues created the sensation of traversing through different architectural scales: from the openness of the urban scale, to the confined street-level scale, to the insulated interiors, and finally, the deeply personal and intimate scale of individual experience. For instance, in one act, the distant rumble of artillery transitioned seamlessly into the immediate echo of footsteps in a narrow corridor, guiding the listener through the auditory landscape of a city under siege.

Reverberation and echo were manipulated to simulate the acoustic characteristics of varied environments, supporting the themes of *Sound as Survival* and *Silence as a Weapon*. The long reverberation of distant explosions contrasted with the sharp, immediate echoes of confined spaces, evoking the duality of expansive urban environments and the claustrophobic interiors where residents sought refuge. Survivors recalled moments of heightened vigilance when the silence between bombings often signaled impending danger. This interplay of sound and silence was reflected in the installation, where pauses and absences of sound heightened anticipation, reinforcing the psychological weight of auditory trauma.

4.2.3. Integrating architecture and memory

By integrating these psychoacoustic principles with the thematic insights of the project, Haris Sahačić transformed sound into an architectural material, reconstructing the spatial and emotional dimensions of wartime Sarajevo. Each act's focus on a distinct urban scale allowed participants to experience the transition from the vastness of the city's besieged outskirts to the intimacy of personal spaces where survival was most immediate. The individual sound miniatures, including the piano melody and the poem, added a deeply personal layer to the soundscape, capturing the duality of resilience and trauma. The installation demonstrated how sound can serve as a powerful tool for recreating architectural experiences, eliciting emotional responses, and engaging with memory and healing. Through its intricate layering of spatial and emotional narratives, 'Symphony of the Siege' offered a profound exploration of how architecture, sound, and memory intersect in the context of collective trauma.

5. Sound performance 'Peace'

The sound performance, 'Peace' by artist Mirada Zećo, serves as the closing component of the 'Sound Lifeline' exhibition, directly following the electro-acoustic piece, it is designed not

simply as a sound therapy session but as a reflective counterpart to the intense sonic journey presented in 'Symphony of the Siege'. It invites visitors into a restorative sonic space, promoting calm and introspection, which helps them process the emotional impact of the previous installation. In the 'Peace' sound performance, psychoacoustic principles were meticulously applied to create a therapeutic auditory experience that contrasted with the intense and visceral nature of the 'Symphony of the Siege' installation. While 'Symphony of the Siege' explored sound as a medium for reconstructing the auditory and spatial realities of war, 'Peace' focused on using sound to foster emotional regulation, introspection, and recovery. This complementary piece leveraged psychoacoustic techniques to transition listeners from heightened states of tension to a calm and reflective state, aligning with trauma-informed therapeutic practices.

5.1. Conceptual foundation and therapeutic design

The design of 'Peace' is grounded in music therapy literature and sound theory, integrating rhythmic and tonal elements that facilitate relaxation and emotional release (Redmond, 2013; Perry, 2009). Unlike 'Symphony of the Siege', which follows a progression from urban to intimate soundscapes, 'Peace' takes an inverted approach: it begins with high-pitched, intense tones and gradually moves to deeper, resonant sounds produced by gongs and therapeutic sound bowls. This descent mirrors a release from heightened alertness to calm, helping listeners process any emotional or somatic responses they may have experienced in 'Symphony of the Siege'.

Central to 'Peace' is the planetary gong tuned to Venus (221.23 Hz), associated with grounding properties, interwoven with calming tones from therapeutic sound bowls in different ranges: a small bowl (200–1,200 Hz), a medium bowl (100–1,100 Hz), and a large bowl (100–2,800 Hz) (Hess, 2008). Each frequency range is chosen for its ability to engage the body and mind, easing the autonomic nervous system and encouraging a state of relaxation and presence. This focus on calming frequencies and rhythms aligns with trauma-informed theories, such as Perry's neuro-sequential model, which posits that rhythmic activities can help regulate the brain's primitive response systems (Perry, 2006).

5.2. Structure and flow: An intentional arc from tension to calm

'Peace' begins with high-pitched, intense sounds that gradually transition to lower frequencies, mirroring the reversal of the urban-to-intimate progression found in 'Symphony of the Siege'. This descent from higher pitches to softer, resonant sounds in 'Peace' allows listeners to shift from emotional alertness to calm introspection. As the sound piece progresses, sound elements such as the ocean drum add a grounding element, helping visitors connect with their physical and emotional states and providing a moment of decompression before reaching silence. This structure reflects the therapeutic aims of 'Peace'. Rather than a fixed composition, the performance uses sound improvisation to respond to the collective experience of the audience, adjusting elements of volume, rhythm, and frequency to allow for a gradual release of tension and anxiety. Silence, which serves as the final element, is an intentional therapeutic choice, providing a space where the auditory experience can settle within the listener, inviting reflection and closure. The intention is for silence to resonate as a calm endpoint, allowing visitors to process both pieces within the context of their own memories and responses.

Frequency manipulation was central to the design of 'Peace'. The performance employed tonal progression from high-pitched, intense frequencies at the beginning to lower, resonant frequencies as the session progressed. High-frequency sounds were used initially to engage listeners' auditory systems and mirror the heightened alertness experienced during trauma. As the performance continued, the use of low-frequency sounds, including those generated by a planetary gong tuned to Venus (221.23 Hz) and large sound bowls, engaged the listener's parasym-

pathetic nervous system, promoting relaxation and grounding. This descending frequency gradient followed principles of frequency-response psychology, which demonstrates how lower frequencies can induce states of calm and meditative focus by slowing brainwave activity. Amplitude modulation played a significant role in guiding listeners' emotional trajectories. Volume fluctuations were carefully controlled, with gradual reductions in sound intensity mirroring a descent from emotional tension to tranquility. These amplitude shifts were complemented by dynamic range modulation, which transitioned from complex, multi-layered soundscapes at the start to simpler, more harmonic tones toward the conclusion. This simplification of the auditory environment symbolically represented the process of emotional unburdening, helping listeners process the intensity of the 'Symphony of the Siege' experience.

The principles of localization and spatial perception were also employed to create an immersive and encompassing auditory field. By using directional sound cues, such as the oscillation of tones between left and right speakers or the gradual emergence of sound from distant to proximate positions, the performance simulated movement through a tranquil, imagined space. These spatial effects were achieved through precise manipulation of interaural time differences (ITD) and interaural level differences (ILD), enabling listeners to perceive shifting sound sources and engage with the spatial dimensions of the performance. This auditory spatialization was designed to evoke a sense of safety and containment, as the enveloping sound created an intimate, protective auditory "space." Binaural beats were subtly integrated into the harmonic structure of the performance. By delivering slightly different frequencies to each ear, the performance induced a perception of rhythmic beats not present in the physical sound. These binaural beats, tuned to frequencies associated with theta brainwave states (4–8 Hz), encouraged relaxation and introspection, fostering a meditative psychological state. This approach aligns with psychoacoustic studies that demonstrate the efficacy of binaural beats in reducing anxiety and enhancing mental focus.

The performance also employed reverberation and echo to shape the auditory environment. Early in the session, moderate reverberation was used to create a sense of expansive space, which gradually decreased as the tones shifted to a more intimate and closer auditory environment. This progression mimicked the listener's journey from external engagement to internal reflection. The controlled decay of sound, particularly in the use of gongs and bowls, contributed to a sustained resonance that allowed participants to "dwell" in each tone, fostering a prolonged meditative state. Silence was strategically used as an integral component of the performance. Toward the end, sound elements gradually faded into extended intervals of silence, emphasizing stillness as a therapeutic endpoint. In psychoacoustics, silence is understood not as an absence of sound but as an active auditory state that encourages introspection and emotional resolution. This final phase invited listeners to process their auditory experiences in a calm and undisturbed environment, integrating the emotional effects of both 'Symphony of the Siege' and 'Peace'.

By harnessing these psychoacoustic principles, 'Peace' transformed sound into a medium for therapeutic architectural space. The auditory progression from tension to calm mirrored the structure of trauma recovery, offering listeners an opportunity to decompress and reflect within a carefully constructed auditory environment. This sound performance demonstrated the capacity of psychoacoustically informed sound design to support emotional and psychological healing, extending its implications to therapeutic and trauma-informed architectural practice.

5.3. Connecting sound therapy to architectural experience

'Peace' extends the architectural theme of 'Sound Lifeline' by illustrating how sound can evoke spatial and emotional dimensions beyond its mere acoustic properties. Traditional architecture

relies on physical materials to create space; here, sound is employed as an "architectural" medium, constructing an environment that supports emotional well-being and processing. The therapeutic effects observed among attendees highlight sound's potential to shape spaces within architectural contexts that support trauma healing. The implications of this project suggest that sound therapy has a role to play within architectural practice, particularly when designing spaces aimed at supporting mental health and emotional resilience. In summary, 'Peace' functions as more than a supplementary sound experience—it is an essential therapeutic bridge within 'Sound Lifeline' that embodies the project's goals of combining architectural and therapeutic sound design. Through 'Peace', the exhibition underscores how sound can blur the lines between architecture and therapy, suggesting new dimensions for trauma-informed architectural spaces.

6. Conclusion

This study advances an innovative understanding of sound as both an architectural and emotional medium, underscoring its transformative potential in shaping spatial perception and addressing collective trauma. Through its exploration of the sonic dimensions of the siege of Sarajevo, the research demonstrates how sound operates as more than an auditory phenomenon, instead functioning as a critical agent in the creation, disruption, and restoration of architectural space. By framing sound as both a representation of memory and an instrument for healing, the project establishes a compelling intersection between architecture, psychoacoustics, and trauma studies.

The thematic analysis of survivor narratives revealed the profound ways in which sound-defined experiences of survival, orientation, resilience, and trauma during the siege. These findings informed the conceptual and artistic outputs of the project, including the electro-acoustic composition and the therapeutic sound performance. The former reconstructed the layered wartime soundscapes across architectural scales, guiding listeners from urban vastness to intimate personal spaces, thereby immersing them in the spatial and emotional dynamics of conflict. In contrast, the latter offered a restorative sound composition, demonstrating the capacity of sound to foster emotional release, introspection, and psychological recovery. Together, these works highlighted the duality of sound in articulating both the trauma of war and the resilience required for healing.

The integration of sound into architectural discourse, as exemplified in this project, redefines the boundaries of architectural practice by incorporating aural elements as fundamental building blocks of spatial experience. Drawing on theoretical frameworks such as Leitner's sound-space concepts and principles of aural architecture, the study advances a paradigm in which sound constructs perceptual environments that parallel—and in some cases transcend—physical structures. This approach not only expands the scope of architectural practice but also suggests novel applications for trauma-informed design, particularly in post-conflict and therapeutic contexts.

The findings and methodologies presented in this study open pathways for future interdisciplinary exploration. By merging empirical research, artistic innovation, and therapeutic practice, the project illustrates the potential of sound to contribute to architectural theory, public history, and trauma recovery. The sensory and emotional dimensions of space revealed through sound enrich our understanding of the built environment, offering a profound lens through which to address the complexities of memory, resilience, and healing in post-conflict settings. Ultimately, this research invites architects, artists, and scholars to rethink the interplay between sound and space, encouraging the development of environments that not only evoke memory but also foster emotional restoration and collective understanding. It is within this convergence of disciplines that new opportunities for meaningful engagement with historical and contemporary trauma can emerge, allowing architecture to serve as a vessel for empathy, reflection, and recovery.

Endnotes

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References

Augoyard, J.-F., & Torgue, H. (2005). *Sonic experience: A guide to everyday sounds*. McGill-Queen's University Press.

Baker, F. A., Gleadhill, L. M., & Dingle, G. A. (2007). Music therapy and emotional exploration: Exposing substance abuse clients to the experiences of non-drug-induced emotions. *The Arts in Psychotherapy, 34*(4), 321–330.

Bevan, R. (2007). *The destruction of memory: Architecture at war.* Reaktion Books.

Blesser, B. (2008). Aural architecture: The missing link. *Journal of the Acoustical Society of America, 124*, 2525.

Blesser, B., & Salter, L.-R. (2007). *Spaces speak, are you listening? Experiencing aural architecture*. MIT Press.

Chase, S. E. (2007). Multiple lenses, approaches, voices. In N. K. Denzin & Y. S. Lincoln (Eds.), *Collecting and interpreting qualitative materials* (3rd ed., pp. 651–679). Sage Publications.

Daughtry, J. M. (2015). *Listening to war: Sound, music, trauma, and survival in wartime Iraq.* Oxford University Press.

Das, V. (2007). *Life and words: Violence and the descent into the ordinary* (1st ed.). University of California Press. Retrieved March 24, 2023, from http://www.jstor.org/stable/10.1525/j.ctt1pprtk

Feniger-Schaal, R., & Amir, D. (2017). Somatic experiencing for children and adolescents exposed to chronic and/or acute trauma: A retrospective study. *Journal of Child & Adolescent Trauma, 10*(4), 407–416.

Fowler, M. (2015). Sounds in space or space in sounds? Architecture as an auditory construct. *Architectural Research Quarterly, 19*(1), 61–72.

Gilman, L. (2016). *My music, my war: The listening habits of the U.S. troops in Iraq and Afghanistan*. Wesleyan University Press.

Glumčević, A., & Odobasic Novo, L. (2021). Shifting morphology: Sarajevo under siege. *Montreal Architectural Review, 7*, 59–83.

Goodman, S. (2012). *Sonic warfare: Sound, affect, and the ecology of fear*. MIT Press.

Grant, M. J., & Papaeti, A. (2013). Music and torture | Music and punishment. *The World of Music, 2*(1). https://www.jstor.org/stable/i24316991

Herman, J. L. (2015). *Trauma and recovery: The aftermath of violence—from domestic abuse to political terror.* Basic Books.

Huyssen, A. (2003). *Present pasts: Urban palimpsests and the politics of memory*. Stanford University Press.

Jordan, L. (2014). Site-specific soundscape design for the creation of sonic architectures and the emergent voices of buildings. *Buildings, 4*(1), 1–24.

LaBelle, B. (2010). *Acoustic territories: Sound culture and everyday life*. Continuum.

Lefebvre, H. (1991*). The production of space.* Blackwell Publishing.

Leitner, B. (1971). SOUND ARCHITECTURE: Space created through traveling sound. *Artforum, 9*(7), 45.

Levine, P. A. (2010). *In an unspoken voice: How the body releases trauma and restores goodness.* North Atlantic Books.

Martinho, C. (2019). Aural architecture practice: Creative approaches for an ecology of affect. https://doi.org/10.25602/GOLD.00026374

Nike, W., & Hinterberger, T. (2022). Neurophysiological effects of a singing bowl massage. *Medicina, 58,* 594. https://doi.org/10.3390/medicina58050594

Nuxoll, C. (2015). 'We listened to it because of the message': Juvenile RUF combatants and the role of music in the Sierra Leone civil war. *Music and*

Politics, 9(1). https://doi.org/10.3998/mp.9460447.0009.104

Ogden, P., Minton, K., & Pain, C. (2006). *Trauma and the body: A sensorimotor approach to psychotherapy.* Norton & Company.

Ouzounian, G. (2006). Embodied sound: Aural architectures and the body. *Contemporary Music Review, 25,* 69–79.

Ouzounian, G. (2021). *Stereophonica: Sound and space in science, technology, and the arts.* MIT Press.

Papaeti, A. (2020). On music, torture and detention: Reflections on issues of research and discipline. *Transposition [Online], Hors-série 2.*

Perry, B. (2006). Applying principles of neurodevelopment to clinical work with maltreated and traumatized children: The neurosequential model of therapeutics. In *Working with traumatized youth in child welfare: Social work practice with children and families* (pp. 27–52). Guilford Press.

Perry, B. (2009). Examining child maltreatment through a neurodevelopmental lens: Clinical applications of the neurosequential model of therapeutics. *Journal of Loss and Trauma, 14,* 240–255. https://doi.org/10.1080/15325020903004350

Perry, B. D., & Szalavitz, M. (2007). *The boy who was raised as a dog: And other stories from a child psychiatrist's notebook.* Basic Books.

Redmond, B. (2013). Drumming and mindfulness: A therapeutic tool for children with emotional and behavioural issues. *International Journal of Therapeutic Communities, 34(*2), 81–94.

Rice, T. (2016). Sounds inside: Prison, prisoners, and acoustical agency. *Sound Studies, 2*(1), 6–20. https://doi.org/10.1080/20551940.2016.1214455

Schlaug, G., Norton, A., Overy, K., & Winner, E. (2005). Effects of music training on the child's brain and cognitive development. *Annals of the New York Academy of Sciences, 1060(*1), 219–230.

Thoma, M. V., La Marca, R., Brönnimann, R., Finkel, L., Ehlert, U., & Nater, U. M. (2013). The effect of music on the human stress response. *PLoS ONE, 8*(8), e70156.

Truax, B. (1978*). Handbook for acoustic ecology.* A.R.C. Publications; World Soundscape Project, Simon Fraser University.

Velasco-Pufleau, L., & Atlani-Duault, L. (2020). Sounds of survival, weaponization of sounds: Exploring sonic lieux de mémoire. *Violence: An International Journal, 1*(2), 265–272. https://doi.org/10.1177/2633002420976674

Velasco-Pufleau, L. (2021). Listening to terror soundscapes: Sounds, echoes, and silences in listening experiences of survivors of the Bataclan terrorist attack in Paris. *Conflict and Society, 7*(1), 60–77.