

LIVING AUDIO SCORES: DESIGNING LISTENING-BASED NOTATION IN NADA SFERA PLAYGROUND

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ABSTRACT

Nada Sfera playground is a web-based live soundscape installation in which environmental audio streams are transformed into musical form through active listening and real-time interaction. Rather than positioning sound as a fixed material to be reproduced or annotated, the system invites visitors to engage with sound as a dynamic, evolving process. Participants shape the sonic outcome by manipulating parameters such as real-time granular synthesis, spatial direction, sound diffusion, and acoustic intensity, allowing each interaction to generate a unique realisation of the work. As the sonic environment is continuously variable and non-linear, performers and visitors require a form of guidance that supports interpretation without prescribing exact outcomes. In response, this paper proposes the concept of living audio scores as a listening-based notational framework for Nada Sfera Playground. These scores function as perceptual roadmaps rather than visual or symbolic representations, guiding musical form through attention, spatial awareness, and textural listening. Where visual or symbolic elements are present, they operate only as secondary orientation cues and do not function as a visual score. By articulating macro-structural trajectories while allowing micro-level sonic variation, living audio scores enable coherent yet open-ended performances within a live soundscape context. The study situates Nada Sfera Playground within contemporary discourse on sound as score, non-visual-focused notation systems, and ecological listening, arguing that listening-based notation offers a viable alternative to reading-oriented score paradigms in web-based and installation-based sonic practices.

1. INTRODUCTION

Musical notation has historically functioned as a visual system designed to encode sound for later interpretation

through reading. From staff notation to ‘graphic’ and animated scores, the act of performance has typically been mediated by visual presentations that prescribe pitch, rhythm, structure, or gesture. While such systems have been extended and challenged throughout the twentieth and twenty-first centuries, particularly within experimental, electroacoustic, and sound art practices, notation remains largely oriented toward visual decoding. In contexts where sound itself is fluid, contingent, or environmentally situated, this reliance on visual representation can become limiting, privileging fixed outcomes over perceptual engagement and reducing listening to a secondary role.

Recent developments in sound-based practices have increasingly foregrounded listening as an active, interpretative act rather than a passive reception of pre-defined material [1, 2]. Within soundscape composition, ecological sound art, and live electronic performance, sound often unfolds as a process shaped by environmental conditions, performer interaction, and system behaviour [3, 4]. In such contexts, the question is no longer how sound should be represented visually, but how musical form can be guided, navigated, and articulated through listening itself.

Within this broader discourse, the notation of sound as score has emerged as a critical framework for understanding how sonic material can function directly as a structuring and instructive element, particularly in live electronic practices where form is realised through interaction and listening [5]. Rather than serving as an object to be notated, sound becomes the primary carrier of musical information, shaping form through its temporal, spatial, and textural properties. This approach aligns with practices that emphasise open form, indeterminacy, and performer-system interaction, where the score is understood not as a fixed artefact but as a set of conditions that enable musical action [6].

This paper contributes to these discussions by proposing the concept of living audio scores, articulated through the design of Nada Sfera Playground, a web-based live

soundscape installation¹. In this system, environmental audio streams are continuously transformed through real-time processes such as granular synthesis, spatial direction, sound diffusion, and dynamic control of acoustic intensity. Each realisation of the work is shaped by interaction and listening, resulting in performances that are recognisable in structure yet never identical in detail. The sonic environment is therefore inherently variable, non-linear, and contingent, resisting fixed representation.

In response to this variability, Nada Sfera Playground introduces a listening-based, non-visual-focused notational framework that does not rely on visual score representation as its primary mode of instruction. Instead, living audio scores operate as perceptual roadmaps, articulating macro-structural trajectories—such as entry, transition, and exit—while allowing micro-level sonic behaviour to emerge through real-time interaction. These scores guide musical form through attention, spatial awareness, and sensitivity to texture, supporting coherent performance without prescribing specific sonic outcomes. Where visual or symbolic elements are present, they function only as secondary orientation cues and do not constitute a visual score.

By framing notation as a process that unfolds through listening rather than reading, this study situates Nada Sfera Playground within contemporary discourse on sound as score, non-visual-focused notation systems, and ecological listening, arguing that living audio scores offer a viable alternative to reading-oriented score paradigms in web-based and installation-based sonic practices.

2. SYSTEM OVERVIEW- NADA SFERA PLAYGROUND

Nada Sfera Playground forms part of the broader Nada Sfera ecosystem, a modular soundscape streaming and interaction framework developed as part of the author's PhD portfolio project *Seed of Life (SoL)*. Established in 2020 as a self-funded pilot project, Nada Sfera comprises three interrelated components: Nada Sfera Binaural Streamer, Nada Sfera Analyser and Nada Sfera Playground. The project has been supported through research and artistic collaboration with Locus Sonus and the Bristol Interaction Group, and has been previously disseminated through the Electroacoustic Music Studies Network Conference (EMS) 2021 [7]. Within this ecosystem, Nada Sfera Playground functions as the performative and notational layer, transforming live environmental sound streams into a listening-driven 'musical' environment.

Nada Sfera Playground is implemented as a web-based interactive sound-art installation utilising the Web Audio API for real-time audio processing, spatialisation, and interaction. Six environmental sound streams are delivered using an internet radio streaming mode based on Icecast, allowing continuous, low-latency transmission of live

binaural soundscapes from remote locations. The system is accessed through a standard web browser, allowing deployment across installation, rehearsal, and performance contexts without dedicated software installation. This platform choice supports accessibility, scalability, and distributed listening while maintaining sufficiently low latency for real-time sonic manipulation.

Environmental audio streams originating from Nada Sfera Binaural Streamer devices are routed into a modular audio graph within the Web audio API framework. Each stream is treated as an independent audio node, enabling individuals control over level, spatial position, diffusion, and granular transformation. The system architecture is deliberately designed to privilege sonic perception over visual feedback; while a minimal interface provides access to control parameters, 'musical' change is perceived primarily through listening. In this way, interaction within Nada Sfera Playground is oriented toward attentional and perceptual engagement rather than screen-based manipulation.

The title "Nada Sfera" reflects both sonic and spatial conceptual grounding. "Nada" refers to sound as a fundamental vibrational principle within South and Southeast Asian musical thought, while "Sfera" evokes spatial and environmental dimensionality. Together, the term situates the project within a framework where sound is understood as both material and space, aligning with the system's emphasis on immersive listening and distributed sonic environments.

2.1. Interaction, Variability, Indeterminacy, and Notational Implications

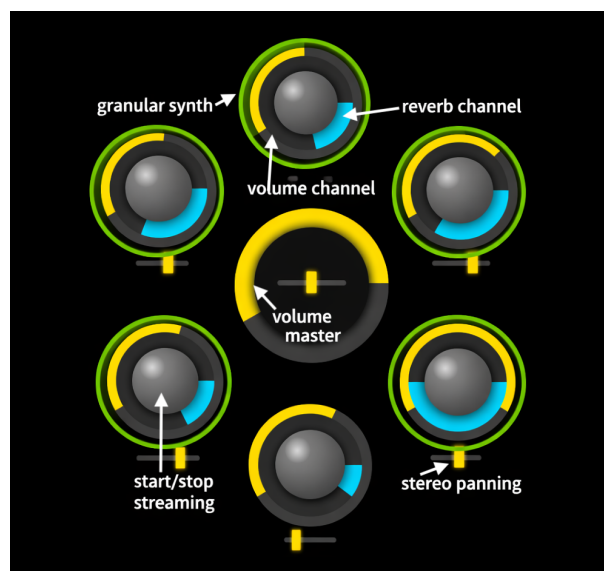


Figure 1. Nada Sfera Playground with improved user interaction (UI) design.

Within Nada Sfera Playground, participants interact with multiple real-time soundscape streams through a set of

¹ Nada Sfera Playground (prototype version) is available online: https://dac.uitm.edu.my/natural_soundscape/NadaSferaPlayground.html. The system is currently under ongoing development and may occasionally be unavailable due to maintenance. As a prototype, certain features, particularly panning and granular synthesis with an updated web

interface layout (see Figure 1), remain under active testing and may not be fully stable or consistently reflected in the online version.

continuous sonic parameters. These include channel activation and level control, spatial direction (panning) at both channel and master levels, sound diffusion articulated through spatial movement and reverberant depth, and real-time granular synthesis applied independently to each stream. Together, these parameters allow sound to transition fluidly between continuous environmental textures and fragmented micro-events, supporting attentive, exploratory listening (see Figure 1).

Importantly, the system does not impose linear progression or fixed ‘musical’ outcomes. Sound streams continue to evolve regardless of user input, positioning participants within an ongoing sonic ecology rather than a reactive instrument. Musical form emerges through sustained interaction, perceptual sensitivity, and the temporal behaviour of the system itself.

A defining characteristic of Nada Sfera Playground is its non-identical repeatability. Variability arises from multiple interacting factors: the contingent nature of environmental sound, the probabilistic behaviour of granular processes, and the interpretative choices of participants. Despite this openness, coherence is maintained through constraints embedded in the system design, such as bounded parameter ranges and gradual response curves.

These conditions establish a performative environment in which sound itself functions as an instructive medium. Rather than encoding musical content symbolically, the system generates a continuously unfolding sonic field that performers and visitors navigate through listening. This framing positions Nada Sfera Playground as a notational environment, preparing the ground for the introduction of living audio scores as perceptual guides that articulate structure without prescribing specific sonic results.

Although the available controls, such as level, panning, diffusion, and granulation, resemble those of a conventional mixing interface, their function within Nada Sfera Playground is fundamentally recontextualised. Rather than optimising balance or clarity, parameter adjustments are guided by perceptual listening states articulated through the score cards. The system therefore shifts from a corrective mixing paradigm to a performative and interpretative one, in which sonic relationships are shaped through attention, spatial awareness, and temporal sensitivity.

A recorded demonstration of a performance realisation of Nada Sfera Playground, including the use of audio score cards, is available at: https://drive.google.com/drive/folders/1BPuFHkree8Mdxn_AJdXZncPQzIAGLIP?usp=sharing

3. LIVING AUDIO SCORE IN NADA SFERA PLAYGROUND VIA AUDIO SCORE CARDS

3.1. Living Audio Scores as Listening-Based Notation

In Nada Sfera Playground, notation is reconceived as a listening-based process rather than a visual or symbolic representation of sound. Musical form is not specified in advance nor encoded through fixed graphical instructions;

instead, it emerges through real-time interaction with a continuously evolving real-time live soundscape. Within this context, the term living audio score refers to a notational framework that exists as an active sonic condition, unfolding through temporal, spatial, and textural change.

The score does not prescribe specific events; instead, it establishes conditions for musical action, aligning with traditions of indeterminacy and open form at the micro-structural level, while framing performance within a perceptually recognisable large-scale arc. Sound itself becomes the primary carrier of notational information, and listening becomes the central interpretative act through which performers and participants navigate form, respond to sonic behaviour, and shape ‘musical’ outcomes. In this model, notation functions as a facilitative process rather than an instructional artefact, supporting coherence without fixing outcome.

3.2. Manual-Pull Audio Score Cards

Navigation within the living audio score is supported through a system of audio score cards [8]. In the current implementation, these cards exist as external performative artefacts rather than embedded interface elements. They may be presented as printed cards or external digital prompts (e.g., screen-based decks), and are interpreted by performers alongside the web interface. Each card articulates a listening state rather than a sequence of actions or a time-based cue. Cards are activated exclusively through a “manual pull” mechanism, meaning that transitions are initiated by the performer based on listening judgement rather than automated timing or system triggers. The term “manual pull” therefore refers to a perceptual decision to shift listening state, not a software-driven event.

This approach explicitly rejects automated progression and elapsed-time logic. The duration of each card remains indeterminate and varies according to sonic behaviour, performer attention, and environmental contingency. As a result, the score remains reactive to sound rather than directive over it, preserving performer agency and foregrounding listening as a performative skill rather than reading as an instructional necessity.

The audio score cards are organised into three primary decks corresponding to a strophic arc-type formal trajectory: beginning, middle, and ending. This structure provides a recognisable large-scale form while avoiding linear timelines or teleological progression. The beginning deck establishes orientation, introducing spatial awareness and a shared listening posture. The middle deck functions as the core performative field, where density, texture, and spatial motion are explored; cards in this deck may be drawn repeatedly and in variable order. The ending deck supports dissolution and release, guiding the gradual withdrawal of sonic activity and attentional focus.

Movement between decks is determined solely through listening judgement rather than temporal markers. Performers may remain within the middle deck for an

indeterminate duration before initiating closure through the ending deck. In this way, the strophic arc provides perceptual clarity while remaining temporally open, allowing form to be realised through experience rather than prescription.

Cards are activated exclusively through a manual pull mechanism, meaning that transitions are initiated by the performer based on listening judgement rather than automated timing or system triggers. The term “manual pull” therefore refers to a perceptual decision to shift listening state, not a software-driven event. Each card articulates a listening intention that is realised through interaction with the system’s available parameters, such as channel level, spatial positioning, diffusion, and granular processing, establishing a consistent relationship between perceptual guidance and sonic outcome without enforcing fixed mappings.

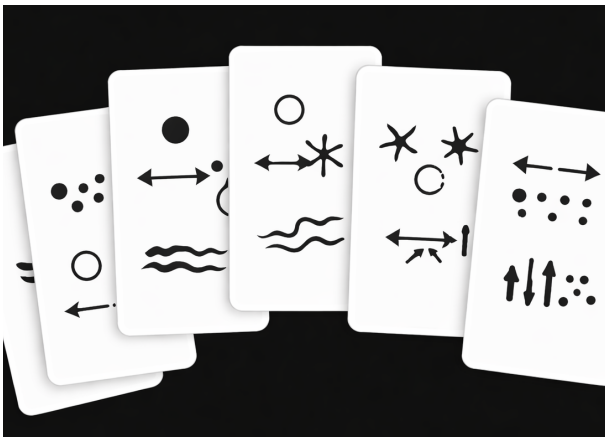


Figure 2. Example of external manual-pull audio score cards used in performance.

3.3. Performance Settings

Nada Sfera Playground supports both solo performance and distributed web-based ensemble realisations. In solo mode, a single performer operates within one web browser, navigating the three-deck card system while shaping the soundscape through listening-driven interaction. This approach relates to emerging browser-based and distributed score systems in which a shared state coordinates performance without prescribing identical actions, extending existing work in networked notation and collaborative digital performance environments [9, 10].

In distributed mode, multiple performers engage simultaneously from separate web browsers, forming a web-based installation ensemble. In this configuration, a shared card state is synchronised across participants, while sonic interaction remains local and interpretative. One participant assumes a scorekeeper role, responsible solely for manual card draws and transitions between the beginning, middle, and ending decks. Other participants respond to the active card by shaping sonic parameters, such as level, spatialisation, diffusion and granulation, through attentive listening.

This separation between a shared notational state and local sonic interpretation aligns with established approaches to network the browser-based score systems, where coordination is achieved without enforcing identical actions [9, 10]. The scorekeeper curates the evolving listening content rather than controlling sound, enabling collective musical behaviour to emerge through distributed listening.

Conceptually, the audio score cards share affinities with indeterminate and instruction-based practices, particularly those associated with Cage’s framing of compositional conditions and Fluxus event scores [11]. Live event scores, the card function as proposals rather than commands, specifying conditions under which musical action may occur rather than prescribing concrete outcomes.

However, unlike many object- or action-based Fluxus scores, Nada Sfera Playground situates instruction directly within an evolving sonic environment. The manual-pull mechanism further aligns the system with active listening and improvisational practice, particularly as articulated in Oliveros’ Deep Listening, where musical decisions arise from sustained attentional engagement with sound [2]. Improvisation here is understood not as gestural virtuosity, but as perceptual responsiveness to sonic change.

3.4. Audio Score Card Perceptual Symbols, Cognition and Interaction

Each audio score card combines short textual prompts with a limited set of perceptual symbols. These symbols do not encode musical parameters nor function as a visual score. Instead, they serve as orientation cues, reinforcing perceptual categories such as presence, distance, motion, and textural state.

The symbol system intentionally employs high-contrast, monochrome forms to minimise visual effort and reduce cognitive load. Research in visual cognition and icon legibility demonstrates that luminance contrast significantly affects recognition speed and response accuracy, particularly in attention-divided contexts [12, 13]. By avoiding colour-dependent encoding, the symbol design improves accessibility for users within colour-vision deficiencies and supports rapid orientation without drawing attention away from listening [14].

This design rationale parallels principles observed in early perceptual development, where which-constrast visual stimuli facilitate rapid pattern recognition. In Nada Sfera Playground, reducing visual complexity allows cognitive resources to remain focused on auditory perception and decision-making rather than visual decoding.

While the audio score cards operate at a perceptual and cognitive level, interaction within Nada Sfera Playground is realised through technical controls such as channel level, spatial positioning, sound diffusion and granular synthesis. The relationship between symbolic cues, perceptual intention, and possible technical approaches is exemplified in Table 1.

Symbols	Perceptual Meaning	Listening Intention	Possible Technical Approaches
●	Presence / Foreground	Bring one sound stream into perceptual focus	Increase relative channel level; reduce reverb send; narrow spatial spread
○	Distance / Withdrawal	Allow sound to recede from attention	Lower channel level; more reverb; widen spatial diffusion; reduce granular density
↔	Lateral Drift	Encourage spatial motion without destination	Apply gradual modulated left-right panning; avoid fixed centre positions
∴	Granular / Fragmented Texture	Attend to micro-events and discontinuity	Increase grain density; randomise grain playback position; shorten grain size
...	Sparse / Pointillistic	Focus on isolated sonic events	Reduce number of active channels; lower grain density; introduce silence between events
◎	Resonant / Distant Space	Attend to spatial depth and reverberation	Increase reverb time and wet signal; diffuse spatial position

Table 1. Nada Sfera Playground Live Audio Score Card performance notes.

Although Nada Sfera Playground embraces indeterminacy and environmental contingency, coherence is maintained

through the combined effect of the three-deck structure, the manual-pull mechanism, and the perceptual consistency of the audio score cards. Across performances, the system exhibits recognisable formal behaviour while allowing substantial micro-level variation arising from sound sources, granular processes, and performer interpretation.

In this way, living audio scores enable ‘musical’ form to remain both open and intelligible. Rather than fixing outcomes, the score supports an ongoing negotiation between sound, system, and listener, demonstrating how notation can function as a dynamic, listening-based practice within web-based and installation-oriented sonic environments.

4. CONCLUSIONS

This paper has introduced living audio scores through the design of Nada Sfera Playground, a web-based live soundscape installation that frames musical form through listening rather than fully visual representation. By combining manual-pull audio score cards with a three-deck strophic arc ‘musical’ form, the system establishes conditions for musical action, while allowing sonic detail to emerge through real-time interaction. The proposed framework supports both solo and distributed web-based ensemble performance, demonstrating how a shared notational state can coordinate collective listening without prescribing sonic outcomes. By positioning notation as a perceptual roadmap rather than a fixed score, Nada Sfera Playground contributes a listening-based alternative to reading-oriented score paradigms, aligned with contemporary sound-as-score practices in web-based and installation contexts.

Acknowledgments

The author gratefully acknowledges the support of Universiti Teknologi MARA (UiTM), Faculty of Music, and the UiTM Computer Music and Musical Acoustics Initiative Research Group (i-COMMA) for supporting this research and the author’s participation in the TENOR Conference 2026. This participation is undertaken in conjunction with the parallel artistic research project supported by the ASEA-UNINET Grant 2025/2025 (ASEA-40/2025), titled Echoes of Tradition: A Cross-Cultural Artistic Research on Folklore and Natural Soundscapes. The author also thanks the collaborating institutions and partners involved in the ongoing development of the Nada Sfera project.

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