

A Musical Tension and Release Framework for Sonic Interaction Designers

Minsik Choi
School of Computing
Australian National University
Canberra, Australia
minsik.choi@anu.edu.au

Alexander Hunter
School of Music
Australian National University
Canberra, Australia
alexander.hunter@anu.edu.au

Josh Andres
School of Cybernetics
Australian National University
Canberra, Australia
experienceplay@gmail.com

Charles Patrick Martin
School of Computing
Australian National University
Canberra, Australia
charles.martin@anu.edu.au

Abstract

Sonic interaction designs can be enhanced by considering the music cognitive processes of tension and release. However, existing design models for applying these principles lack accessibility for practitioners, and practical guidelines remain underdeveloped. We propose a practitioner-oriented framework for designing sonic interactions that foregrounds music cognition concepts. Our framework connects music cognition and interaction design by aligning methods for functional harmony with workflow analysis. We articulate a cohesive three-step strategy, extendable for advanced practitioners, and explore opportunities for generative AI to support the design process. Our design framework links theoretical foundations in functional harmony and workflow with practical applications, aiming to accessibly create sonic interactions that effectively communicate with users. This work contributes design guidelines for practitioners, promoting the broader adoption of musical tension and release, and setting the stage for future empirical research.

CCS Concepts

• **Applied computing** → **Sound and music computing**; • **Human-centered computing** → **User interface design**.

Keywords

Sonic Interaction Design, Tonal Cognition, Framework, GenAI

ACM Reference Format:

Minsik Choi, Josh Andres, Alexander Hunter, and Charles Patrick Martin. 2025. A Musical Tension and Release Framework for Sonic Interaction Designers. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '25)*, April 26–May 01, 2025, Yokohama, Japan. ACM, New York, NY, USA, 7 pages. <https://doi.org/10.1145/3706599.3720089>

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

CHI EA '25, Yokohama, Japan

© 2025 Copyright held by the owner/author(s).

ACM ISBN 979-8-4007-1395-8/25/04

<https://doi.org/10.1145/3706599.3720089>

1 Introduction

Musical engagement has often been reflected in interaction design to serve both aesthetic and functional goals [19, 45]. As music permeates everyday life, exploring how individuals engage with it and leveraging this understanding in the design of interactive systems is a persuasive strategy. Listening is an inclusive form of musical activity [48], and the cognitive processes—such as following the tension and release within musical structures—have been extensively studied [22, 23]. For example, iconic songs by artists like The Beatles resonate across generations, enabling listeners to share common cognitive experiences without particular training [11]. These principles have informed sonic interaction design, where sound signals are used to influence user behaviour, bridging movement sonification and embodied music cognition [26]. The movement by musical embodiment, referred to as tonal cognition [9], has been conceptually explored in sonification research [38, 50] and applied in guiding workflow through experimental studies [29, 31]. Newbold et al. [30] introduced a design model, but a gap remains in translating these principles into guidelines for practitioners, limiting their applicability for those without expertise in music or interaction design.

The design model from Newbold et al. [30] interprets three sonic interaction cases through embodied tonal cognition but does not consider practical application. Although this approach aligns with similar design frameworks in sonic interaction design [21, 27, 39], it may bypass hands-on analysis methods in interaction design and tonal music. Moreover, these studies often treat tonal cognition under broad terms like embodiment, metaphor, or music, which makes it challenging to grasp the specific effects of tonal principles and their theoretical depth. While some research has attempted to develop practical guidelines [14, 16], these efforts are grounded in broad theoretical reviews and lack accessible solutions, still requiring some expertise in both interaction design and music. Prototype creativity support tools (CSTs) that use generative AI (GenAI) to generate design options [15] promise to assist with this skill gap, but such solutions are so far not backed by a solid framework.

In this paper, we present a practical framework for designing sonic interactions informed by tonal cognition—musical tension and release—while exploring the opportunities presented by GenAI. Building on prior studies by Newbold et al. [30] and Choi et al. [15],

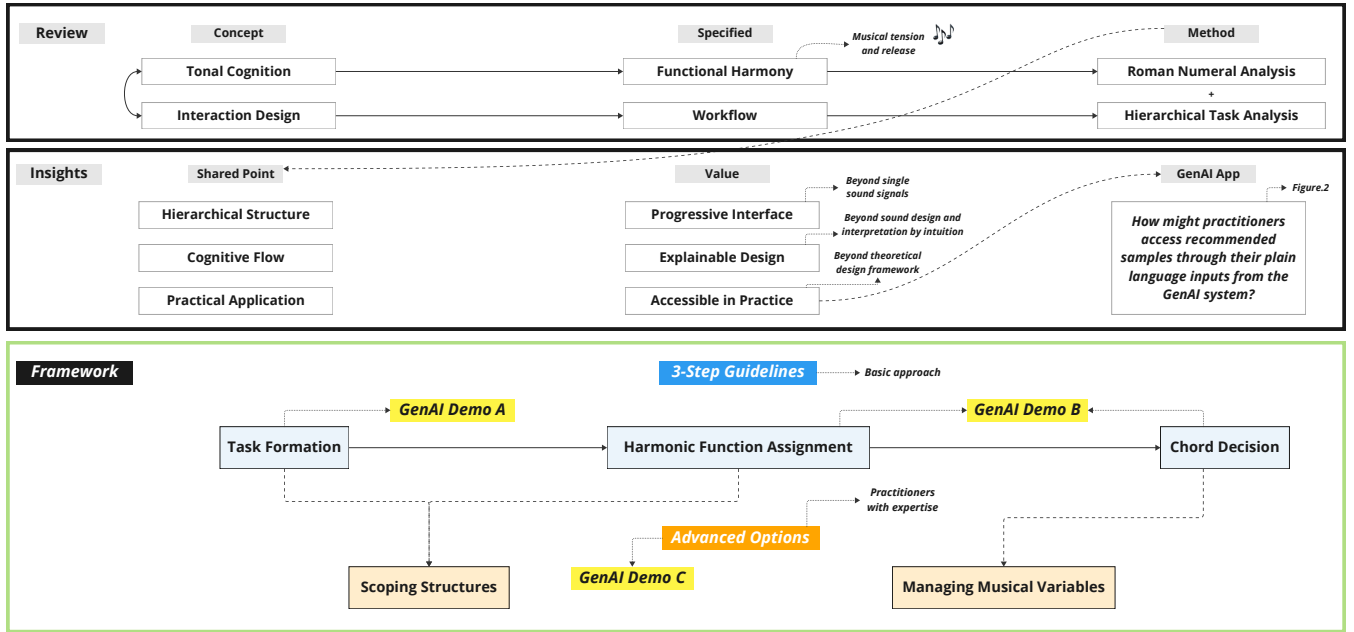


Figure 1: Research overview: theoretical review, insights for framework development, and a sonic interaction design framework for practitioners using musical tension and release, featuring 3-step guidelines, 2 advanced options, and 3 GenAI applications.

we provide step-by-step guidelines for practitioners and explore advanced options. We also highlight how GenAI can enhance the design process through plain-language input. The framework development procedure follows these steps:

- First, we provide a top-down overview of key concepts in tonal cognition and interaction design, narrowing the focus to functional harmony, workflow, and associated methods such as Roman numeral and task analysis.
- Next, we derive insights by synthesising these concepts and methods into a cohesive sonic interaction design strategy applying musical tension and release, while identifying the role of GenAI in the design process.
- Finally, we introduce the framework, which includes 3-step guidelines, 2 advanced options, and 3 demonstrated GenAI opportunities.

We then discuss the implementation of the framework, exploring how it can be applied and tested through CST development for future sonic interaction design research.

In summary, our contributions are three-fold: (1) we establish a detailed theoretical foundation for sonic interaction design with tonal cognition; (2) we propose a practical framework with step-by-step guidelines for practitioners, along with advanced considerations and GenAI opportunities; and (3) we reflect on the framework application through CST development in future sonic interaction design research. Although these were not empirically tested within the scope of this study, they provide a foundation for future research to test these ideas and develop subsequent CSTs upon these initial insights, referencing a similar late-breaking framework design by Lazaro and Kim [25].

2 Theoretical Review

This section begins by providing an overview of key concepts, movement sonification through embodied tonal cognition, as outlined by Newbold et al. [30]. It explores tonal cognition and interaction design in greater depth, setting the groundwork for understanding the two distinct layers of the design strategy. This review then narrows to targeted concepts, functional harmony and workflow. The concepts are paired with practical methods: Roman numeral analysis for functional harmony and hierarchical task analysis for workflow. Finally, insights from the comprehensive review are discussed to propose a framework incorporating GenAI opportunities, as suggested by Choi et al. [15]. This integrates the two layers into one design strategy and examines the potential for leveraging GenAI within the design process.

2.1 Tonal Cognition and Interaction Design

Embodied cognition challenges cognitive science by emphasising the role of the body in shaping the mind [46]. Similarly, embodied music cognition views the body as a mediator between musical experience and sound [2, 26]. Among the ecological and corporeal dimensions [26], the structural relationships within tonal music further illustrate the ecological aspects of embodied music cognition [24]. Tonal music is hierarchically structured around harmonic functions, creating a system that resolves back to tonic through tensions of dominant [8]. Musicologists, from Jean-Philippe Rameau to contemporary theorists, have studied the structural relationships, primarily with regard to Viennese classicism of the 18th and 19th centuries [6]. Listening to tonal music has been explored as tonal cognition through musical expectancy via the hierarchy of tonal stability within musical syntax [23]. Syntactic processing in tonal

music encompasses harmonic functions and broader tonal structures, with systematic analysis methods such as Martin Rohrmeier’s generative syntax model [22, 41, 42]. This conception has been practically applied to interaction design, where tonal cognition informs user behaviour, often in the context of psychological studies. The potential of applying tonal cognition to sonic interaction design has been addressed in the interplay between musical applications and sonification design [38, 50], validated through practical implementations [10, 29, 31], and supported by conceptual frameworks [30, 39].

Roddy and Bridges [39] proposed a framework for overall mapping strategies in sonification, defining parameters based on embodied cognition models, while Newbold et al. [30] focused on integrating musical expectancy into movement sonification. Together, these frameworks provide a conceptual foundation for applying embodied music cognition to sonic interaction design. This foundation can be further clarified through the concepts of functional harmony and workflow. Functional harmony aids in analysing sonic interfaces by revealing hierarchical structures in sound progressions, extending beyond the understanding of how people process tonal music. Workflow emphasises tasks in detail, focusing on how sound is applied to particular tasks rather than broad interaction or movement. These concepts can also bridge the gap to practical analysis methods, such as Roman numeral analysis and hierarchical task analysis. Combining these methods aligns progressive sound functions with user task flows and can enable practitioners to improve practicality and effectiveness in sonic interaction design.

2.1.1 Functional Harmony. Functional harmony defines chordal relationships through three key functions—tonic, subdominant, and dominant—forming the basis of chord progressions [34]. Chords built on each scale degree (from the first to the seventh) have hierarchical relationships that resolve to the tonic, creating progressions that sound cognitively coherent to listeners [37]. In short, the tonic (first degree and sixth as a substitute) is a start and ending point, dominant chords (fifth and seventh degrees) transition to the tonic, subdominant chords (fourth and second degrees) lead to the dominant and chords on the third and sixth degrees serve as intermediates [18]. Other movements such as from the subdominant to the tonic introduce variations within the broader frame, along with factors like chord types, cadences, and inversions [35]. The overarching progression follows a sequence of tonic, subdominant, and dominant, with compositional variables adding diversity to tonal music. Weber [51] introduced the now widely used Roman numerals representation of chords based on scale degrees (e.g., I, IV, and V for first, fourth, and fifth degrees), which illustrates the functional coherence of harmonic progressions [7]. Compared to chord symbols often used in jazz and popular music, Roman numeral notation offers a method for understanding harmonic functions that cognitively aligned with listeners [5].

2.1.2 Workflow. Optimising interactions between users and products requires considering human factors, including the context of use [40]. Understanding the context of use involves analysing workflows, focusing on the sequential order of specified tasks [28]. Various approaches to understanding workflows, such as journey maps, user scenarios, and task analysis, address different aspects but share a foundation in story-driven causality [32]. Journey maps, commonly used in service design, organise a user’s sequence of

events as touchpoints along a horizontal timeline [32, 43]. Similarly, scenarios in design depict imagined narratives of system use, focusing on actors, agendas, context, and action sequences [1, 13, 44]. From a goal-oriented perspective, task analysis systematically represents the psychological complexity of tasks, with hierarchical task analysis (HTA) further breaking down workflows into tasks and sub-tasks [4]. In HTA, each subtask is defined by its goal, the conditions or plans that activate it, the actions required to achieve it, and the feedback that confirms its completion [3]. The basic steps for conducting an HTA include defining the purpose, establishing boundaries such as stakeholders, detailing tasks and sub-tasks, and accounting for factors like conditions or plans [49]. Organising tasks hierarchically aligns the user’s cognitive process with the workflow, enhancing interaction design by providing clear task specifications and a cognitive understanding of the context of use.

2.2 Insights into Framework Development

Our above review identifies two shared points between functional harmony and workflow as shown in Figure 1. These are the hierarchical structure underlying both progressive sound and task sequences, and the cognitive flows corresponding to sound and task progressions. These two common points can be integrated into a unified concept of hierarchically structured cognitive flows. The workflows can be structured around the cognitive phases of tasks within a hierarchical task specification. Corresponding harmonic functions can then be selectively applied to suitable tasks, maximising the communicative effect of the auditory interface through cognitive alignment. Roman numeral analysis documents harmonic functions within chord progressions, while HTA can capture the hierarchical structure of a workflow, providing a basis where harmonic functions can be cognitively applied. The basic steps of the framework are hierarchical task formation, harmonic function assignment to relevant tasks, and chord decision. Advanced options for skilled practitioners can additionally address multiple structural scopes and further musical variables. As mentioned in Choi et al. [16], this strategy provides a logical foundation for progressive auditory interface design, extending beyond discrete displays, and enabling interpretation for design itself and subsequent user evaluation. More importantly, this insight goes beyond the conceptual understanding of the strategy. Through the practical approaches of Roman numeral analysis and HTA, it becomes accessible to practitioners in sonic interaction design.

Furthermore, we could identify the potential of applying GenAI to the design process to enhance user accessibility. As first addressed in Choi [14] and explored further in Choi et al. [16], the need for design samples and the translation of jargon into plain language was recognised for the CST in sonic interaction design. Additionally, Choi et al. [15] applied GenAI features to CST development, drawing on similar applications for CST advancement [17, 20, 33, 47]. This strategy is closely aligned with the current research purpose, aiming to update the conceptual design framework into practical guidelines. The function could provide design sample suggestions, generated by GenAI based on plain-language input from practitioners. As demonstrated through the prototype by Choi et al. [15], features—ideation for writing the storyboard, generating chord

progressions, and creating note arrangements—will be initially considered; however, the features will be further refined based on the current framework including the guideline and advanced options.

3 Framework

We propose a framework for applying tonal cognition in sonic interaction design through 3-step guidelines, accompanied by 2 advanced options and 3 GenAI potentials (Figure 1). Drawing on insights from the theoretical review that combines harmonic functions with workflow, the guideline helps practitioners apply musical tension and release to relevant user tasks through a step-by-step process, using Roman numeral analysis and hierarchical task analysis. The advanced options explore considerations for scoping structures and managing further musical variables. Finally, we explain how GenAI aids practitioners during the proposed process, along with brief demonstrations.

3.1 Three-Step Guidelines

The **first step** is task formation through HTA. HTA is systematic, uses specific terminology, but remains adaptable to different purposes [3]. This guideline uses adjusted terms, such as purpose, phase, user, task, and plan, as referenced in Annett [3]. The purpose defines the intent and direction of the overall analysis, similar to the theme of a storyboard in Choi et al. [15], while the phase outlines a distinct stage for task specification. The user refers to the individual performing the tasks, the task represents the specific actions taken by the user, and the plan offers additional instructions, such as conditions, iterations, or decision-making rules, to guide execution. Below are the steps for task formation along with a rear parking example for clarity.

- (1) Decide the purpose and the user(s) of your analysis; for example, rear parking is the purpose of the analysis, and the user is typically the driver, though it may include other passengers depending on the context.
- (2) Plan the phases based on the decided purpose and user(s); for example, exploration, entrance, and correction can outline each stage of rear parking for a driver.
- (3) Decompose tasks; the overall process can be arranged in parallel, with subtasks within each superordinate task described vertically. For example, if entering a parking space is a task of the parallel process, subtasks such as checking risk factors, steering, and moving into the space can be described vertically.
- (4) Specify plans; for example, instructions may be needed for iterating the entrance phase to correct parking positions.

The **second step** is assigning harmonic functions to relevant tasks. Three tonal functions—tonic, subdominant, and dominant—are mapped to tasks based on the user's cognitive flow. Drawing from a previous study [15], we use intuitive terms to describe cognitive states: start, rising, peak, and end. These terms make it easier for practitioners to assign functions: start and end correspond to tonic, rising to subdominant, and peak to dominant. Prolongation is used when a single function applies continuously across multiple tasks.

- (1) Decide where sounds are applied; select the tasks where auditory interfaces will be used. For example, sound can be

assigned to moving into the parking space and reaching the acceptable range.

- (2) Assign harmonic functions(cognitive states); based on cognitive flows, harmonic functions are assigned to selected tasks. For example, moving into the parking space can be assigned as the rising or peak, creating tension, while reaching the acceptable range can be assigned as the end, providing release.

The **third step** is to determine chord details based on the assigned functions. The tonal key is established first, with chords notated using Roman numerals: I for start and end, IV for rising, and V for peak. Alternative chords, like ii for IV, vii° for V, and vi for I, offer the same functional intent with different chordal colours. Roman numerals represent the note positions from the tonic, so in C major: I–C, ii–D, iii–E, IV–F, V–G, vi–A, vii°–B [36].

- (1) Select the tonal key; choose a tonal key, such as C major, a minor, etc, by selecting either a major or minor scale and its tonic as the first note. As a basic guideline, any tonal key among the 12 tones and scales can be chosen without affecting the design logic. Practically, major keys are often perceived as more uplifting and bright, while minor keys are more melancholic and dark, as discussed in Choi et al. [16].
- (2) Decide chord types and note composition; based on the assigned functions and tonal key, select appropriate chords. Follow the representative chords for each cognitive state, using basic triads or single notes from each scale degree. For example, in C major, the peak (V) can be G, B, D and the end (I) can be C, E, G, assigned to tasks like moving into the space and reaching the acceptable range.

3.2 Advanced Options

It may be appropriate for experienced practitioners to explore more advanced options within this framework such as scoping structures and managing further musical variables. Scoping structures involve analysing tasks and tonal functions at varying levels, such as micro and macro perspectives [5], allowing for multiple structures that enable more detailed analysis and refined sound applications. Managing musical variables expands on chord variations and incorporates other elements like timbre, dynamics, and more, providing creative variations within the same design strategy. Scoping structures relate to task formation and function assignment, while managing musical variables ties into chord decision in the guidelines. These discussions are also illustrated with the rear parking example.

Our design strategy can be refined by incorporating different scopes. Since both harmonic structures and HTA share hierarchical layers, sound design can be planned progressively under macro and micro perspectives. For example, at the superordinate level, a basic tonic-dominant-tonic structure can create global tension and release. Within each layer, sub-harmonic progressions can be elaborated to specify the finer details of each broad phase. This approach can also involve key changes, such as modulating to the dominant key and returning to the tonic key, similar to the sonata form [12], to create structural tension in the overall design. For instance, in the rear parking example, sound is assigned to two phases: entrance and confirmation. The entrance phase holistically focuses

A Task Formation

4

Task Specification

Provide a task specification about rear parking consisting of 4 actions, aligned with hierarchical task analysis and considering driver as the user. Please simply list the tasks as bullet points.

- "**Assess the Parking Space**" - Evaluate the dimensions of the parking space - Check for obstacles and surrounding vehicles - "**Initiate Reverse Maneuver**" - Shift the vehicle into reverse gear - Use mirrors and rearview camera to monitor surroundings - "**Steer and Control Vehicle**" - Gradually turn the steering wheel to align with the parking space - Control the vehicle's speed using the brake and accelerator - "**Finalize Parking Position**" - Monitor the proximity to curb and other vehicles - Shift into park gear once the vehicle is correctly positioned

B Harmonic Assignment and Decision

6 tasks *Number of assigned tasks*

C Key

major Scale

Start

Rising

Continue

Warning

Peak

End

Chord Progression

Note Arrangement

Provide 3 chord progression options in C major key for 6 measure(s), following the tonal functions in the order specified by: tonic, subdominant, prolongation, nonchord, dominant, tonic. Please simply list the options as bullet points.

Here are three chord progression options in the key of C major for 6 measures, following the specified tonal functions: - "**Option 1**": C (Tonic) - F (Subdominant) - C/E (Prolongation) - G7/B (Nonchord) - G (Dominant) - C (Tonic) - "**Option 2**": C (Tonic) - F (Subdominant) - Am (Prolongation) - Dm7 (Nonchord) - G (Dominant) - C (Tonic) - "**Option 3**": C (Tonic) - F (Subdominant) - C/G (Prolongation) - E7 (Nonchord) - G (Dominant) - C (Tonic)

Provide 3 harmonic note arrangement options (including inversions) for 4 voices based on G B D with suitable octave numbers. Please simply list the options as bullet points.

Here are three harmonic note arrangement options for 4 voices based on the notes G, B, and D, including inversions: - "**Option 1**": Voice 1: G4 - Voice 2: B4 - Voice 3: D5 - Voice 4: G5 - "**Option 2**": Voice 1: B3 - Voice 2: D4 - Voice 3: G4 - Voice 4: B4 - "**Option 3**": Voice 1: D3 - Voice 2: G4 - Voice 3: B4 - Voice 4: D5

C Advanced Options

6 phases *Number of planned phases*

C Key

major Scale

classical Musical genre

Start

Rising

Continue

Mood Shift

Peak

End

Key Modulation

Provide 3 key modulation sets starting from C major for 6 parts, following the tonal functions in the order specified by: tonic, subdominant, prolongation, relative or parallel, dominant, tonic key(s). Please simply list the options as bullet points.

Here are three key modulation sets starting from C major for 6 parts based on the specified tonal functions: ### Modulation Set 1: - "**Tonic**": C major - "**Subdominant**": F major - "**Prolongation**": D minor (ii in C major) - "**Relative or Parallel**": A minor (relative minor of C) - "**Dominant**": G major - "**Tonic Key(s)**": C major ### Modulation Set 2: - "**Tonic**": C major - "**Subdominant**": F major - "**Prolongation**": E minor (iii in C major) - "**Relative or Parallel**": A minor (relative minor of C) - "**Dominant**": G major - "**Tonic Key(s)**": C major ### Modulation Set 3: - "**Tonic**": C major - "**Subdominant**": F major - "**Prolongation**": B diminished (vii° in C major) - "**Relative or Parallel**": A minor (relative minor of C) - "**Dominant**": G major - "**Tonic Key(s)**": C major These sets provide a structured approach to the tonal functions specified while maintaining coherence within the tonal framework of C major.

Provide 3 altered chord options for Gmaj based on classical style in C major key. Please simply list the options as bullet points.

- Gmaj7 (G - B - D - F#) - G6 (G - B - D - E) - G7 (G - B - D - F)

Figure 2: Demo for GenAI opportunities: green represents user inputs, and blue indicates corresponding questions by the GenAI system. A. Task formation with inputs for target task, user, and number of actions. B. Harmonic assignment and decision, with inputs for chord progression based on task number, key, scale, and cognitive states in sequence. The note button generates chord components using Tonal.js for note arrangement. C. Advanced options for key modulation and altered chords, with inputs for phase number, key, scale, and cognitive states for modulation, along with musical genres and a user-provided chord for altered chords.

on building tension, while the confirmation phase emphasises release, incorporating sub-harmonic progressions with smaller sets of tension and release, as well as potential key changes between the phases through the dominant and tonic keys.

After task formation and function assignment, chord decision focuses on shaping the sound characteristics. While the guideline suggests a basic approach with triads or single notes, practitioners with expertise can explore alternatives like 7th chords, inversions, non-chord tones, or advanced chords serving the same functions, keeping in mind the relationship of tonic and dominant. Adding the 7th note of chords, varying inversions of selected chords, or incorporating altered chords and non-chord tones enables diverse note arrangements. For instance, while moving into the parking space, non-chord tones can be used as warning sounds when approaching a hazard, within the same functional prolongations. Altered chordal options in different musical genres, such as augmented 6th chords and secondary dominants for subdominant function, can further enhance tension and add unique sound colours beyond the standard chords. Additionally, once the tonal structure and chords are set, other musical variables, such as timbre and dynamics, can be customised to refine each sound signal, akin to the process of acoustic tuning.

3.3 Generative AI Opportunities

We propose potential entry points for GenAI into our design strategy that might bridge the knowledge gap for practitioners without music experience. How might practitioners access recommended samples through their plain-language inputs from the GenAI system? While the guidelines are designed to be intuitive for practitioners without expertise, it can be further supported by enabling them to ask questions requiring expertise to LLMs in plain language. Building on the features outlined in Choi et al. [15], we expanded the functions to support the application of our design framework involving the guidelines and advanced options. We developed a Node.js web demo leveraging the OpenAI GPT-4o API to showcase how the refined GenAI features support practitioners in applying our design strategy (Figure 2). The source code is available online¹.

GenAI can assist with task formation by outlining structures and providing options through plain-language questions (A in Figure 2). Inputs include defining a broad task, such as a phase or superordinate task, the potential number of specified actions, and the user performing the actions. Once all inputs are set, a pre-structured question is automatically generated for the GenAI system, yielding recommended samples. Similarly, harmonic function assignment and chord decision follow a parallel process (B in Figure 2). Inputs include the number of tasks assigned for sound application, the

¹<https://github.com/Yorkcla/GenAI-demo-for-MTRSID>

cognitive states of the tasks, and a tonal key. Cognitive states are represented as start, rising, peak, end, and warning, and the same states can apply to multiple tasks as prolongation. The states are translated into the terms of functional harmony in the query to ask the GenAI system. Note arrangements can also be suggested for a given chord within the recommended harmonic progressions for various applications. The system offers an ‘any’ option for certain inputs, such as the number of tasks and the tonal key, to enable flexible ideation. Furthermore, advanced options can be explored, such as tonal key changes between phases to create structural tension or mood shifts, and chord variations with altered chords in different musical genres while maintaining logical progression (C in Figure 2).

4 Discussion and Conclusions

We have proposed a framework for sonic interaction design based on tonal cognition, featuring step-by-step guidelines and advanced options for practitioners. Additionally, we have explored the potential of integrating GenAI into this framework to provide recommendations via plain-language inputs. This framework aims to bridge the gap between conceptual studies and practical applications, and the GenAI insights extend beyond previous systems for improved accessibility, aligning with the current framework. Practitioners can begin with the structured guidelines, which hierarchically integrate sound signals and tasks with cognitive flows, while those with expertise can refine their designs with the advanced options. Finally, the insights into GenAI applications highlight opportunities for making the design strategy even more approachable for practitioners.

In developing the framework, tonal cognition and interaction design were reviewed with a focus on harmonic functions and workflow, leading to two shared points: hierarchical structures and cognitive flows in sound and task progressions. Building on these insights, straightforward guidelines were composed of three steps: task formation, harmonic function assignment, and chord decision. Additionally, advanced options were introduced for scoping structures and managing musical variables. These options, aligned with the guidelines, allow expert practitioners to create diverse sound outputs from multiple perspectives. GenAI opportunities were envisioned to assist practitioners by converting plain-language inputs into expertise, supporting phases of the guidelines and advanced options.

The next phase of implementing the framework focuses on its application and evaluation through the development of a CST. This CST would act as an intuitive all-in-one interface for the suggested design strategies, connecting practitioners with the proposed framework, similar to the prototype developed in Choi et al. [15]. The tool could be a web application inspired by the reference prototype, or developed as a plug-in for seamless sound tuning with commonly used software. User studies, such as design workshops and experimental approaches, could refine the prototype and promote a practitioner-focused integration of the framework. Practitioners could engage with the CST through an interconnected design platform spanning different phases, incorporating guidelines, advanced options, and GenAI opportunities from the current design framework, making it more tangible and accessible.

In conclusion, this study provides a practical foundation for applying tonal cognition in sonic interaction design, grounded in conceptual exploration. Theoretical insights were addressed through a top-down review, and an accessible framework was developed based on these insights, demonstrating its foundational value as a late-breaking contribution. Although the proposed framework was not empirically tested within this study, future CST development will enable its implementation and evaluate its usability, building on the foundation established in this research. Overall, our work contributes a design framework for practitioners, linking academic outcomes with practical applications at the intersection of sonification and interaction design, leveraging the tension and release in our musical engagement.

References

- [1] Josh Andres, Chris Danta, Andrea Bianchi, Sungeon Hong, Zhuying Li, Eduardo Benitez Sandoval, Charles Patrick Martin, and Ned Cooper. 2024. Understanding and Shaping Human-Technology Assemblages in the Age of Generative AI. In *Companion Publication of the 2024 ACM Designing Interactive Systems Conference* (IT University of Copenhagen, Denmark) (*DIS '24 Companion*). Association for Computing Machinery, New York, NY, USA, 413–416. doi:10.1145/3656156.3658403
- [2] Josh Andres, Rodolfo Ocampo, Hannah R Feldman, Louisa Shen, Charlton Hill, Caroline Pegram, Adrian Schmidt, Justin Shave, and Brendan Wright. 2024. On the Design and Study of an Installation for Office Workers to Amplify Temporal Diversity and Connection to Nature. In *Proceedings of the 15th International Conference on Computational Creativity*. Association for Computational Creativity (ACC). https://computationalcreativity.net/iccc24/papers/ICCC24_paper_17.pdf
- [3] John Annett. 2003. Hierarchical task analysis. In *Handbook of cognitive task design*. CRC Press. doi:10.1201/9781410607775
- [4] John Annett and Neville Anthony Stanton. 2000. Research and Developments in Task Analysis. In *Task analysis*. CRC Press. doi:10.1201/9781482289275
- [5] Bruce Benward and Marilyn Nadine Saker. 2008. Chords. In *Music in Theory and Practice* (8th ed.). McGraw-Hill.
- [6] David Bernstein. 2002. Nineteenth-century harmonic theory: the Austro-German legacy. In *The Cambridge History of Western Music Theory*. Cambridge University Press. doi:10.1017/CHOL9780521623711
- [7] David Bernstein. 2002. Tonality. In *The Cambridge History of Western Music Theory*. Cambridge University Press. doi:10.1017/CHOL9780521623711
- [8] Wallace Berry. 1987. Tonality. In *Structural functions in music*. Courier Corporation.
- [9] Emmanuel Bigand and Bénédicte Poulin-Charronnat. 2016. Tonal cognition. In *The Oxford handbook of music psychology*. Wesleyan University Press. doi:10.1093/oxfordhb/9780199298457.013.0006
- [10] Jorge Boehringer, Marcin Pietruszewski, John Bowers, Bennett Hogg, Joseph Newbold, Gerriet Sharma, Tim Shaw, and Paul Vickers. 2022. Listener-centred Sonification Practice as Transdisciplinary Experimental Artistic Engagement. In *New Paradigms for Music Research. Art, Society and Technology*. Publicacions Universitat de València.
- [11] Kenneth L Campbell. 2021. The Beatles: Today... and Tomorrow. In *Fandom and the Beatles: The Act You've Known for All These Years*. Oxford University Press, USA. doi:10.1093/oso/9780190917852.003.0009
- [12] William E Caplin. 2013. *Analyzing classical form: an approach for the classroom*. Oxford University Press, USA.
- [13] John M Carroll. 2003. *Making use: scenario-based design of human-computer interactions*. MIT press.
- [14] Minsik Choi. 2023. Music theoretical approach to auditory interface design: progressive, explainable, and accessible. In *Proceedings of the 15th Conference on Creativity and Cognition*. doi:10.1145/3591196.3596814
- [15] Minsik Choi, Josh Andres, Alexander Hunter, and Charles Patrick Martin. 2024. Scenario-Based Design to Envision How GenAI Can Support Sound Design Practices. In *Proceedings of the 36th Australian Computer-Human Interaction Conference*.
- [16] Minsik Choi, Josh Andres, and Charles Patrick Martin. 2024. Tonal Cognition in Sonification: Exploring the Needs of Practitioners in Sonic Interaction Design. In *Proceedings of the 19th Audio Mostly Conference: A Conference on Explorations in Sonic Cultures*. doi:10.1145/3678299.3678321
- [17] Richard Lee Davis, Thiemo Wambsganss, Wei Jiang, Kevin Gonyop Kim, Tanja Käser, and Pierre Dillenbourg. 2024. Fashioning Creative Expertise with Generative AI: Graphical Interfaces for Design Space Exploration Better Support Ideation Than Text Prompts. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*. doi:10.1145/3613904.3642908

- [18] Randall Harlow, Heather Peyton, Jonathan Schwabe, and Daniel Swilley. 2022. Functional Harmony. In *Comprehensive Musicianship, A Practical Resource*. UNI ScholarWorks, Rod Library, University of Northern Iowa. <https://iastate.pressbooks.pub/comprehensivemusicianship/>
- [19] Thomas Hermann, Andy Hunt, John G Neuhoff, et al. 2011. Sonic Interaction Design. In *The sonification handbook*. Logos Publishing House. <http://sonification.de/handbook>
- [20] Purnima Kamath, Fabio Morreale, Priambudi Lintang Bagaskara, Yize Wei, and Suranga Nanayakkara. 2024. Sound Designer-Generative AI Interactions: Towards Designing Creative Support Tools for Professional Sound Designers. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*. doi:10.1145/3613904.3642040
- [21] Prithvi Ravi Kantan, Erika G Spaich, and Sofia Dahl. 2021. A metaphor-based technical framework for musical sonification in movement rehabilitation. In *The 26th International Conference on Auditory Display*. doi:10.21785/icad2021.008
- [22] Stefan Koelsch. 2012. Musical Syntax. In *Brain and Music*. John Wiley & Sons.
- [23] Stefan Koelsch. 2012. Perception of Pitch and Harmony. In *Brain and Music*. John Wiley & Sons.
- [24] Marina Korsakova-Kreyn. 2018. Two-level model of embodied cognition in music. *Psychomusicology: Music, Mind, and Brain* (2018). doi:10.1037/pmu0000228
- [25] May Jorella Lazaro and Sungho Kim. 2024. Mind the Mix: Exploring the Cognitive Underpinnings of Multimodal Interaction in Augmented Reality Systems. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems*. doi:10.1145/3613905.3650874
- [26] Marc Leman. 2008. *Embodied music cognition and mediation technology*. MIT press. doi:10.7551/mitpress/7476.001.0001
- [27] Pieter-Jan Maes, Jeska Buhmann, and Marc Leman. 2016. 3Mo: a model for music-based biofeedback. *Frontiers in neuroscience* (2016). doi:10.3389/fnins.2016.00548
- [28] Martin Maguire. 2001. Context of use within usability activities. *International journal of human-computer studies* (2001). doi:10.1006/ijhc.2001.0486
- [29] J Newbold, N Gold, and NL Bianchi-Berthouze. 2017. Musical expectancy in squat sonification for people who struggle with physical activity. In *The 23rd International Conference on Auditory Display*. doi:10.21785/icad2017.008
- [30] Joseph Newbold, Nicolas E Gold, and Nadia Bianchi-Berthouze. 2020. Movement sonification expectancy model: Leveraging musical expectancy theory to create movement-altering sonifications. *Journal on Multimodal User Interfaces* 14 (2020), 153–166. doi:10.1007/s12193-020-00322-2
- [31] Joseph W. Newbold, Nadia Bianchi-Berthouze, Nicolas E. Gold, Ana Tajadura-Jiménez, and Amanda CdC Williams. 2016. Musically Informed Sonification for Chronic Pain Rehabilitation: Facilitating Progress & Avoiding Over-Doing. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. doi:10.1145/2858036.2858302
- [32] Lene Nielsen. 2024. Personas, Scenarios, Journey Maps, and Storyboards. In *User Experience Methods and Tools in Human-Computer Interaction* (1st ed.). CRC Press. doi:10.1201/9781003495161
- [33] Jeongseok Oh, Seungju Kim, and Seungjun Kim. 2024. LumiMood: A Creativity Support Tool for Designing the Mood of a 3D Scene. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*. doi:10.1145/3613904.3642440
- [34] Grove Music Online. 2001. *Function*. doi:10.1093/gmo/9781561592630.article.10386 Retrieved 25 Nov. 2024.
- [35] Walter Piston. 1966. *Harmony*. Gollancz.
- [36] Walter Piston. 1966. Scales and Intervals. In *Harmony*. Gollancz.
- [37] Walter Piston. 1966. Tonality and Modality. In *Harmony*. Gollancz.
- [38] Stephen Roddy and Brian Bridges. 2018. Sound, ecological affordances and embodied mappings in auditory display. In *New Directions in Third Wave Human-Computer Interaction: Volume 2-Methodologies*. Springer. doi:10.1007/978-3-319-73374-6_12
- [39] Stephen Roddy and Brian Bridges. 2020. Mapping for meaning: the embodied sonification listening model and its implications for the mapping problem in sonic information design. *Journal on Multimodal User Interfaces* (2020). doi:10.1007/s12193-020-00318-y
- [40] Yvonne Rogers, Helen Sharp, Jenny Preece, and Helen Sharp. 2023. What is Interaction Design? In *Interaction Design: Beyond Human-Computer Interaction* (6th ed.). John Wiley & Sons.
- [41] Martin Rohrmeier. 2007. A generative grammar approach to diatonic harmonic structure. In *Proceedings of the 4th sound and music computing conference*.
- [42] Martin Rohrmeier. 2011. Towards a generative syntax of tonal harmony. *Journal of Mathematics and Music* (2011). doi:10.1080/17459737.2011.573676
- [43] Mark S Rosenbaum, Mauricio Losada Otalora, and Germán Contreras Ramírez. 2017. How to create a realistic customer journey map. *Business horizons* (2017). doi:10.1016/j.bushor.2016.09.010
- [44] Mary Beth Rosson and John M Carroll. 2007. Scenario-based design. In *The human-computer interaction handbook*. CRC Press. doi:10.1201/b11963
- [45] Stefania Serafin, Bill Buxton, Bill Gaver, and Sara Bly. 2022. Sonic Interaction Design. In *Auditory Interfaces*. Focal Press.
- [46] Lawrence Shapiro. 2019. Introduction. In *Embodied cognition*. Routledge.
- [47] Yulin Shen, Yifei Shen, Jiawen Cheng, Chutian Jiang, Mingming Fan, and Zeyu Wang. 2024. Neural Canvas: Supporting Scenic Design Prototyping by Integrating 3D Sketching and Generative AI. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*. doi:10.1145/3613904.3642096
- [48] Christopher Small. 1998. Prelude: Music and Musicking. In *Musicking: The meanings of performing and listening*. Wesleyan University Press.
- [49] Neville A Stanton. 2006. Hierarchical task analysis: Developments, applications, and extensions. *Applied ergonomics* (2006). doi:10.1016/j.apergo.2005.06.003
- [50] Paul Vickers. 2016. Sonification and music, music and sonification. In *The Routledge Companion to Sounding Art*. Routledge. doi:10.4324/9781315770567
- [51] Gottfried Weber. 1832. *Versuch einer geordneten Theorie der Tonsetzkunst*. Vol. 1. B. Schott's Söhne.