Non-Visual Beats: Redesigning the Groove Pizza

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ABSTRACT
Unlike past eras in which select few had the means and connections to compose music, today almost anyone can engage in meaningful music making and craft their own compositions thanks in part to the ubiquity of affordable and easy-to-use music software. However, this advancement has not fully extended to non-sighted users as evidenced by online communities seeking and offering help and third party companies that have stepped in to fill a void of accessibility features. To address the lack of alternative input modalities and pervasive visual design of music creation software, we redesigned the Groove Pizza [12], a popular online rhythm application. This work describes our implementation and its use of custom keyboard mappings for sequencing rhythm, screen reader output using text-to-speech and sonification, and global audio settings designed for different use cases.

CCS Concepts
•**Human-centered computing** → **Accessibility technologies;** *Sound-based input / output;*

Author Keywords
Accessibility; Music technology; Music creation; Blindness; Visual impairments.

INTRODUCTION
The opportunity to engage with music in any capacity should be available to all. Fortunately music technologies have introduced many new entry points. Beyond performing in school, young people increasingly discover and share music online and play music video games with friends [22]. Software, such as Apple's GarageBand [2], contains libraries of royalty-free musical phrases called loops that allow users to compose entire songs before knowing how to read music, while websites and apps offer affordable music instruction [4]. Inexpensive home recording tools and free music sharing websites have dramatically altered the music industry opening up new pathways for people to produce professional sounding music and expose it to wide audiences [15].

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Recent studies demonstrate the use of technology in music therapy [11, 17, 20, 24], while hardware interfaces like the Skoog [25] and Soundbeam [26] broaden music participation for people with motor and cognitive impairments. Few music applications have been developed explicitly for blind musicians, (an exception being the Braille Music Notator [23]), and no prior published studies to our knowledge have investigated the experiences of blind and visually impaired people who use publicly available music software. Mass market music applications should not require sight for entry, but a significant portion appear to be inaccessible ranging from especially challenging at best to completely unusable at worst. Digital audio workstations (DAWs) such as Ableton Live [1] and GarageBand utilize standardized designs that inhibit non-sighted use with graphic user interfaces containing hundreds of visual controls and indicators on-screen at once. For instance, the piano roll, a widely-used interface element for representing MIDI data, a standard music technology protocol, encodes pitch, duration, and velocity information of musical events within a two-dimensional grid of colorful rectangles. Without an ability to drag-and-drop objects on the grid, a user must navigate long lists of musical event data.

In many cases, companies and developers of music software fail to include accessibility features, or require users to venture deep into application settings to improve accessibility. The internet is rife with tutorials and blogs pertaining to visual access of music software. For example, an online tutorial demonstrates how colorblind users of Finale [16], a notation software for generating sheet music, can create a custom color palette [10], a multi-part podcast series helps blind GarageBand users get up to speed with available key commands [5], and a case study of the iOS version of GarageBand spells out which features are accessible and which are not [3]. Furthermore, individual developers and small companies have taken up the mantle of adding accessibility features such as braille music exporting, increased screen reader support, hot keys that expand functionality, and magnification for those with low vision. One developer Dancing Dots [7], which has existed for nearly thirty years, builds products that enhance specific music applications primarily through the addition of JAWS [9] screen reader support. Third party accessibility patches cost consumers extra money on top of base software and can cease to work when operating systems and music applications undergo major changes.

GROOVE PIZZA REDESIGN
The Groove Pizza [12] is a free, web-based, drum step-sequencer developed by the NYU Music Experience Design

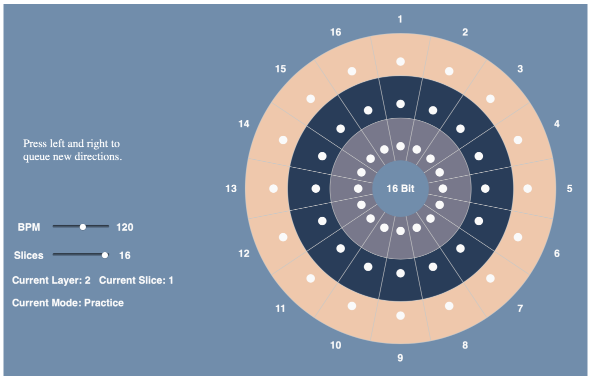

Figure 1. A screenshot of the Groove Pizza redesign, devoid of musical events aka "toppings", containing three concentric circles each holding sixteen clear nodes. Each circle refers to a drum sound, while each node when toggled plays a drum hit. Text onscreen indicates that the playback tempo is 120 beats per minute, the loop contains sixteen beats referred to as slices, the current audio setting is "Practice Mode," and the instrument set is called "16 bit." An instruction indicates that pressing the arrow keys will display new instructions.

Lab (MusEDLab) that reaches thousands of users per month. Originally released within an educational initiative called Math Science Music [13], the Groove Pizza is called a "pizza" because unlike most rectangular sequencers it is circular affording a visualization of beat patterns with geometric shapes. Users, ranging from children to adults, add musical events called "toppings" through clicking nodes or dragging shapes on screen. Two authors are Groove Pizza developers. We are aware most features are incomprehensible to screen readers. The application is primarily represented with SVG images, accessed through clicking "invisible" UI layers, and responsive through custom animations. For this work, we sought to prototype an experience that is fun, explorable, and understandable regardless of visual ability. Our redesign, developed for web browsers and built with the Javascript libraries Tone.js, p5.js, and p5.speech, for text-to-speech, most closely adheres to universal design principles offering a singular experience for people with diverse visual abilities. It addresses two main challenges: the need for keyboard input that makes sense given the affordances of the underlying instrument, and the need for screen reader output that adequately replaces visual stimuli without hindering the music making experience. We invite readers to compare the original Groove Pizza [18] with the prototype discussed in this work [21].

Designing for Keyboard-Only Input

While the original Groove Pizza only supported mouse input on computers, our re-implementation fully supports keyboard input. The TAB key iterates through global settings and instructions while the arrow keys change the value of the focused element or displayed instruction. The rest of the keys directly control the Groove Pizza and result in sound. The mapping from computer keys to audio output is crucial to the experience of using and understanding the Groove Pizza functioning in the same capacity as the arrangement of white and black keys on a piano or strings and frets on a guitar. We have implemented multiple mappings in preparation for future user tests. In one rhythm mapping, the top row of letters on a typical keyboard (Q–P) toggles odd-numbered nodes, while the second row of letters (A–L) toggles even-numbered nodes. This mapping takes advantage of a feature of most western music in which even-numbered beats sound "off of" the pulse. Thus, standard rhythms are created safely with the top row of letters, while wilder, more syncopated rhythms involve the second row of letters. For instance, pressing 'Q' and 'T' with the kick drum selected and then 'E' and 'U' with the snare drum selected results in a simple alternating pattern found in many songs like Michael Jackson's "Billie Jean" [14]. In another rhythm mapping, designed to promote clarity of input and reduce the number of keys required for use, the top row of letters selects a grouping of four consecutive nodes while the second row of letters toggles a node within the selected grouping.

Text-To-Speech and Sonification Output

A challenge in developing music software that supports non-visual use is balancing multiple competing audio streams. Music output interferes with audio display output (text-to-speech) making it hard for any user to understand the effects their interactions are having. Conversely, non-music sounds are undesirable in performance and improvisational settings. We found while testing our text-to-speech implementation that robotic voice output could become distracting and potentially hinder creativity. For this reason, we use sonification [8], or informative non-speech sounds. Prior work has shown that sonification is useful for conveying simple information [19].

We implemented three audio output modes: practice, sonification, and performance. In "Practice Mode" music volume is diminished while text-to-speech sounds are amplified. In "Sonification Mode" most text-to-speech sounds are replaced by synthesized tones that trigger on interaction. The pitch of the tones encodes the position within the loop selected, while the timbre indicates whether a musical event is currently present or absent. In "Performance Mode," all text-to-speech and sonification is disabled and music volume is increased. While we were motivated by informal user tests with undergraduate research assistants in which new users failed to understand the text-to-speech, the distinction between exploratory and performative settings is not novel in music technology. For instance, Max MSP [6], a popular visual music programming environment, contains "Patching" and "Presentation" modes.

DISCUSSION AND CONCLUSION

Our work identifies important questions and introduces new design ideas to be evaluated in the space of non-visual computer music making including customizable keyboard mappings for rhythm sequencing and audio display settings based on use case scenarios. While we have spoken to two blind musicians about their experience with music technology and received prototype feedback from one blind non-musician, visually impaired users have not yet contributed to development or undergone a formal user test. We will directly involve disabled stakeholders in future work and continue to iterate before making permanent changes to the Groove Pizza. More research is necessary to understand the experiences of blind and visually impaired people who seek to learn and use music technologies.

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