Dancing Lights: Supporting Dance Performances for Deaf and Hard of Hearing People through Lighting Effects

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ABSTRACT

Dance is a performing art form consisting of purposefully selected sequences of human movement, and music is an indispensable element of dancing. For people who are deaf and with hearing impairment, some have overcome their hearing challenges through extended practicing by imitating the movement of those who can hear. Inspired by our user research with an amateur dance group, we present Dancing Light, a system that supports dance performances for DHH people. The system automatically recognizes the music being played and provides visualization to DHH dancers through lighting devices set in the environment. This project aims to create a shared dance practice and performance space where hearing is not the only way to feel music. Instead, the environment provides users with different cues to create a more immersive dancing experience for DHH dancers.

CCS CONCEPTS

• **Human-centered computing** → **Accessibility technologies**; *Visualization design and evaluation methods.*

KEYWORDS

Assistive technology; Deaf and Hard of Hearing; Visualization; Dance performances

INTRODUCTION

Over 5% of the world's population — or 466 million people — have some degree of hearing loss [1]. Dance with music, meanwhile, has been a popular activity for people to express their emotions. For deaf and hard of hearing (DHH) people, however, it is not easy for them to do so due to their difficulties connecting themselves with music, especially with its crucial components such as rhythm or tone. Despite those difficulties, dancing with music has been shown to benefit people's physical development [2, 8] and cognitive development [5] while providing opportunities for individuals to interact with others. Therefore, improving the accessibility of dance for DHH performers is worth exploring.

For recreational practices or performances, the DHH dancers often rely on visual cues such as videos from displays or gestures from additional assistants near the dancing location. The most challenging part is that the DHH dancers need to recall the dance steps meanwhile following the rhythm of the music by understanding the simultaneous visual aids. Some past research [7, 9] have tried alternative vibrotactile feedback to imply the ongoing rhythm. Our investigations are based on and further extended from the previous findings, seeking more insights during the process.

Our study focuses more on the specific scenario in which a group of DHH people tried to practice the dance in an indoor space. The interactions between the DHH dancers and their instructor (or leader) are the key to the overall experience. To better understand the problems in such a scenario, we first interviewed members of an amateur dance group. After discussion, we went through a personal immersing experience for dancing without hearing with the dance group. We then went through a brainstorming session that summed up some implications for our initial design.

To prompt the rhythm of the music, our initial design tried to utilize the variation of environmental light as the main visual aid. We tested the conceptual prototype with the aforementioned amateur dancing group during their daily practice session. With the collected feedback, we finalized our designs to build a more accessible dance environment for DHH dancers.

Figure 1: The side shot from the dancing group we interviewed with

USER RESEARCH

Our user research includes literature reviews, user interviews with an amateur dance group, and an immersive experience in which we wore earplugs and joined the group's weekly practice. Besides the information from online articles and footage that DHH dancers identify beats through vibration cues from audio sources and floors, by empathizing with DHH dancers through practical experience, we have a concrete understanding of how they dance without hearing beats and notes. This insight guides our initial design.

Figure 2: We interviewed two dance group members to comprehend their problems.

Figure 3: We analyzed our interview result with post-its and affinity diagram to dig for DHH dancers' needs and insights.

Literature review

We first conducted a literature review to better understand the ethnographic aspects of the DHH dancer community. We found little difference between the learning and teaching process for DHH and hearing dancers, except the latter requires additional visual aids and louder music [4]. With these observations, demonstrating the essential components of music (e.g., rhythm) has been shown as the key to improving the overall experience. Some prior works have investigated how assistive devices that communicate music through vibrations could enhance the overall experience for DHH dancers [3, 6]. Other works extended such concept and tried to understand how that kind of feedback affects the dance experience [7, 9]. These studies show that visual clues are crucial to our design, while additional haptic feedback might play a supported role in the overall experience.

User interviews

We interviewed the group's agent and two female group members aged around 35 from an amateur dance group called *Half Note*. With one mild and the other moderate hearing loss, they are capable of lip reading and inarticulate but understandable speaking. The interview lasted for about an hour. During the interview, we asked them about their experiences with dancing to music, their problems during the process, and some preliminary thoughts on the previous solutions.

Immersive experience

To entirely comprehend the difficulty of dancers with hearing impairment, we wore earplugs and danced with the dance group for a two-hour complete practice cycle from warm-up to cooling-down. Though the earplugs didn't block off all sound and the beats could still be detected, we surprisingly found ourselves unconsciously relying more on others, for example, tactile senses, just as people with hearing impairment do in their daily lives. Though somewhat vague for us to identify beats, the vibration transferred from the floor still serves as a complementary way for them to feel the music. At the end of the practice, we also conducted brief post-interviews with the instructor and more group members to collect more opinions.

Findings

After analyzing the result of the interview and the immersing experience, we found that the relation between a dancer and a song with dance moves could be divided into two phases: practicing the song in a room and giving the performance. We will discuss our findings respectively in the following parts.

Practicing. Before practicing, the first step is to learn a new song with new dance moves. It is straightforward that the more a dancer practices, the better they learn. Hence, we would put learning and

practice together in discussion. Besides, as they spend most of their time practicing with other members in lessons, and observing how they practice alone in their own time is more offending, we would concentrate on helping them in their weekly classes.

To learn a new dance, memorizing dance moves and feeling the rhythm of a song are indispensable for all dancers. For dancers with hearing impairment, there are two additional difficulties: accurately catching the moment a song starts its beats and aligning tempos counted in minds with the music played. Currently, the instructor assigns a volunteer without hearing loss or herself to count tempos with fingers and sometimes step on the floor to make vibrations. However, their hands often get sore as the lesson progresses to the second hour. Various movements and dance formations can also block dancers' sight.

Giving performances. Another phase is performing on stage. It is tougher as the one who counts tempos with fingers can sometimes only sit at audience seating or far from the stage. In a performance area, aligning tempo with others is more difficult as there is no mirror like their routine practice in a dance room. In addition, vibration, traditionally viewed as an effective way for dancers with hearing impairment to feel the music, is inaccurate as it transfers faster through the ground than sound through the air when speakers are far from the stage.

Nonetheless, despite those obstacles, performing is not as terrible as it seems through our observation, for they have gone through massive practice, which, therefore, is the real problem. We would conclude our design point of view with all the mentioned findings and propose our solution.

INITIAL DESIGN

With the results from the interview with the dancers and the immersive experience, we concentrated our design on helping DHH dancers practice with other group members. We conclude that they need a way to feel tempos and align their dancing speeds with others easily, so they can completely savor the dancing experience instead of being occupied with checking the instructor's gestures and sensing the vibration from the floors.

In addition, though haptic feedback, immunized against the blocking problem that the visual feedback suffers, is still a significant way DHH people rely on to gain information from the world, as we mentioned in the user research, vibration is not always the ideal cue to beats in a song due to its vulnerability to body movement. Thus we kept it for future development and dedicated ourselves to design with visual feedback.

Hence, we proposed `Dance Light`, a set of visual feedback devices. With Dance Light, hearing is no longer the only way to feel music in any space where dancers with different degrees of hearing impairment dance together.

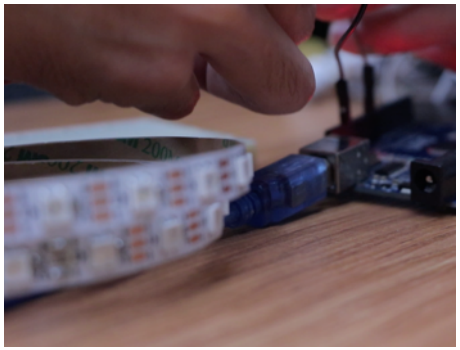

Figure 4: Prototype design of Dance Light.

Dance Light

Dance Light is mainly a lighting strip set in the environment, which can be applied to two scenarios where it provides different functions depending on whether the music is played.

When the dancers go through the song and the music is played, our strip can automatically detect the beats and give visual prompts with a designed pattern. For example, the color pattern can be continuous white or four colors as a cycle to tell measures. In addition, the lighting pattern can also be set as the whole strip twinkles simultaneously like a bar or flickers from one end to the other.

When the instructor is demonstrating dance moves, the music is not played. Then, a controller for the instructor or other hearing people can manually control the lighting strip.

Implementation. Dance Light comprises a beats-detecting algorithm and an LED strip connecting to an Arduino board. The algorithm first analyzes the given music file and outputs the seconds where it identifies beats. When the music file starts to be played, the algorithm then records audio with a short duration from a microphone and finds the place of recorded audio in the original music file. Finally, the current playing time of the input music is found; the algorithm starts counting time and sends the flashing signal to the LED whenever the music plays at the second where a beat is.

USER FEEDBACK

We have invited the group members of Half Note to test our prototype. Despite the algorithm's lack of robustness and accuracy, everyone was interested in our lighting strip and even started to design the lighting pattern. They concluded that the algorithm should find the first beat in every measure and tell the starting points, such as a red flash followed by three white flashes in a four-four time song, so they can easily match the light their learning experience, in which they often memorize dance moves with counts from 1 to 8.

FINAL DESIGN

The preliminary testing result was generally positive and inspiring. The group members' suggestions about extra information a song offers for dancing in addition to beats, such as measures, also encouraged us to consider what a hearing dancer can get apart from obvious beats and notes.

One of the significant elements would be the structure of a song, especially when verses or chorus repeat themselves many times in a song. A hearing dancer can easily memorize dance moves of songs composed of repetitive structure, for the same parts of a song often correspond to the same moves.

Thus, we are developing the algorithm with structure and measures analysis in the preprocessing of a music file. The color pattern of the lighting strips would also be designed to provide information about the structure via colors. The second prototype testing is expected to come in a few weeks and will help us generate deeper insights.

CONCLUSION

In this project, we aimed to enhance the dance experience for DHH people. With interviews and immersive user research with an amateur dance group, we found that DHH dancers need a way to feel tempos and align their dancing speeds with others easily, so they can dedicate themselves to polishing their postures and dancing skills. Hence, we proposed Dance Light, a device composed of LED strips and a controller, to provide visual feedback on the beats of songs. Then, in the prototype test, the opinions from group members inspired us to consider providing hints about the additional information, such as structures and measures. Thus, we are working hard on developing a new algorithm and expect to conduct our second prototype test soon.

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