"It's Like Being on Stage": Staging an Improvisational Haptic-Installed Contemporary Dance Performance

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Abstract. There is increasing research exploring how to augment expressive movements in dance practices by using haptic technologies. Meanwhile, less is known about how the audience perceives such information. In this study, we explore the potential of using a haptic wristband to convey contemporary dancers' performative somatic information to the audience through real-time control of haptic feedback by a haptic DJ. We then evaluate audience members' expectations towards the haptic-enabled viewing dance in a public performance setting. Participants indicated satisfaction with the improvisational haptic dance viewing experience.

Keywords: Haptic · Wearable Device · Dance Performance.

1 Introduction

Stage performance is an important part of the art form of dance that allows dancers to convey emotions and expressive movements [3]. Previous researchers have explored the potential of interactions between dancers and novel technologies, such as tracking dancer body movement to control drone swarms [15], or visualising the sound of muscle using mechanomyogram (MMG) data on stage [33]. However, the researchers also explored the audience's perception of these new performative experiences. Some performances brought audience members closer to the stage by improving the somatic experience of the performers using interactive systems in singing [14] and dancing [23]. Others took the reactions of the audience members to the dance stage by projecting their physiological data to the background [27], or incorporating posts on social networks and haptic feedback [17].

Audience experience can now be enhanced through multimodal sensory approaches, and haptic feedback has been explored in art and performances [9]. For example, utilising haptic interaction to enable a robot to partner stepping with expert dancers [6], and delivering the sensation of tap dance to hearing-impaired using haptic feedback [26]. While these works explored performers' evaluation and the interactive system architecture, less is known about the audience's experience on these haptic dance performances in the wild, and how they can potentially contribute to the future of digital media installations and the entertainment industry.

Inspired by these previous works, we set to explore the feasibility of adding a new figure, a haptic DJ, to convey a dancer's lived experience in dance to the audience using haptic feedback. To do so, we worked with a contemporary dance group to design the haptic choreography of a piece of their signature stage performance[2] using a haptic wristband installed with a VP2 Vibro-Transducer. We then staged the performance in a public theatre, and used the Arts Audience Experience Index (AAEI) [21] to evaluate the audience experience. We collected 131 valid responses from the audience members, and found overall satisfaction from the audience towards the haptic-enabled viewing experience. We summarise our three main contributions in this study: (1) we propose a haptic-installed dance performance to demonstrate the feasibility of using real-time improvisational haptic feedback to augment audience experience, (2) we conducted a public stage performance to identify the audience experience of our haptic-installed dance performance, (3) we found that the improvisational haptic performance is well received, providing a greater sense of presence, and new insights to the audience.

Fig. 1. Haptic DJ during the actual performance

2 Related Works

2.1 Technology Explorations in Dance and Stage Performance

Previous dance research investigates the potential of interactive technology in learning and increasing the expression of somatic information. Researchers investigated how motion tracking and monitoring technologies such as accelerometers [29], motion capture systems [31, 35], and physiological sensors [18] can be used for the assessment of movement quality to improve the learning, practising, and performing experience of

dancers. In parallel, using physiological data to augment dancers' somatic information during performance is another popular approach since dancers' physiological status and flow state show correlation [11]. For instance, using motion capture systems to capture dancers' movements in real-time to control background graphics [10], music [13], and virtual costumes [12]. Another branch of research used robotic manipulators to map dance movements [22, 24]. In general, the technical implementations introduced above showcased how the act of capturing and quantifying the physical movements of dance benefits from the advancement of different interactive technologies. At the same time, there is less exploration on technical approach representing the expressiveness and dancer's intention.

2.2 Understanding the Audience Experience

There are growing voices about empowering the audience in art performances [1]. Audience participation in live performances has been found to be supportive of the promotion of social and mental health [20], and highly engaging performances are efficient in eliciting the feeling of empowerment for the audience [30]. Theodorou et al. [28] used video recording to assess the audience's physical movements during a performance, and proposed the potential of using stilled motion as an indicator of the audience's level of engagement. Cerratto-Pargman et al. [5] analysed the role of communication as a tool for audience participation in interactive performances, and discovered that expectations about the technology impact the audience's experience and interpretation of participation. In sum, these investigations demonstrate the increasingly important role of audience participation, as art performances are now transforming into more digital and interactive manners.

2.3 Haptic Experience in Art and Performance

Haptic technology has been employed in public art and performance-related research. For example, Vi et al. [34] installed a mid-air haptic experience inside a six-week art exhibition. Dima et al. [7] added tactile sensation to museum artefacts that are typically impossible to touch. Besides these explorations on enhancing the public exhibition experience, there are also systems created for dance performances. For example, McCormick et al. [16] developed a system for capturing dancers' movements using motion capture, and mapping it to haptics in real-time to the audience. Sasaki et al. [23] built an audio-haptic feedback system that can deliver the tap dancing sensation to groups of dancers, dancer students, and the audience. While most of these systems are designed to convey the physical movements of dancers to the audience, how to convey the expressive information of more vague artistic performances, such as contemporary dance, where a group of dancers usually perform different and improvisational movements at the same time, remains unknown. Therefore, we decided to incorporate a new figure, the haptic DJ, to reflect the dancers' embodied knowledge.

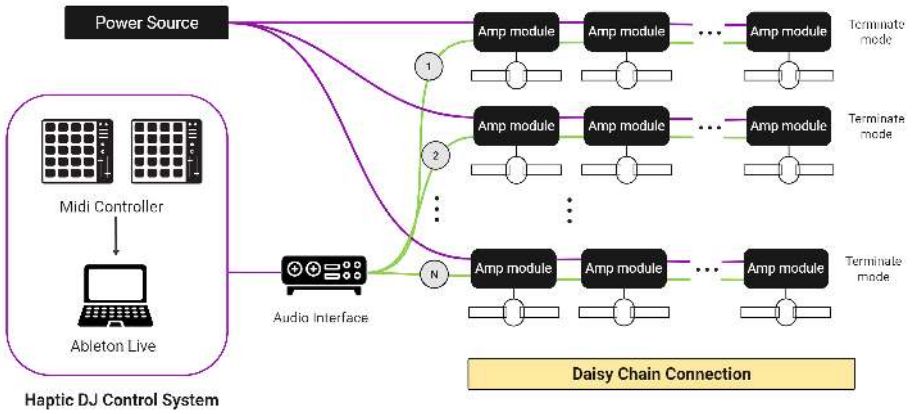

Fig. 2. Haptic system overview, including the Haptic DJ Control System and connection of the wearable device.

3 Designing An Improvisational Haptic-Installed Dance Performance

3.1 Haptic System Overview

Our system consists of (1) two midi keyboard controllers, (2) a laptop installed with the Ableton Live software, and (3) haptic wearable devices for the audience.

Haptic DJ Control System The Haptic DJ prepared basic haptic pattern files such as different *sine waves* on Ableton before the performance, and mainly adjusted the volume to control the intensity of vibrations and the timing of the sample file.

Haptic Hardware and Connection Design The haptic wearable device consists of two key components: (1) a VP2 Vibro-Transducer, and (2) a slap bracelet. We chose a wearable format and the slap bracelet so that the audience could easily adjust or remove the device by themselves at anytime.

We also designed a haptic amplifier unit that allows for daisy chaining connections (see Figure 2), which features power and audio signal output for the wearable device. We then implemented an amplifier ratio adjustment function inside each haptic amplifier unit, to ensure the intensity of the haptic stimulation is consistent for each participant.

We highlighted that a potential hardware limitation for this system is the latency in the stimuli caused by the DJ's delayed response to the dancers' performance.

3.2 Haptic Choreography in each performance scene

Contemporary dance is characterized by its improvisational nature and freedom of expression [8], which often deviates from the strict synchronization with music compared

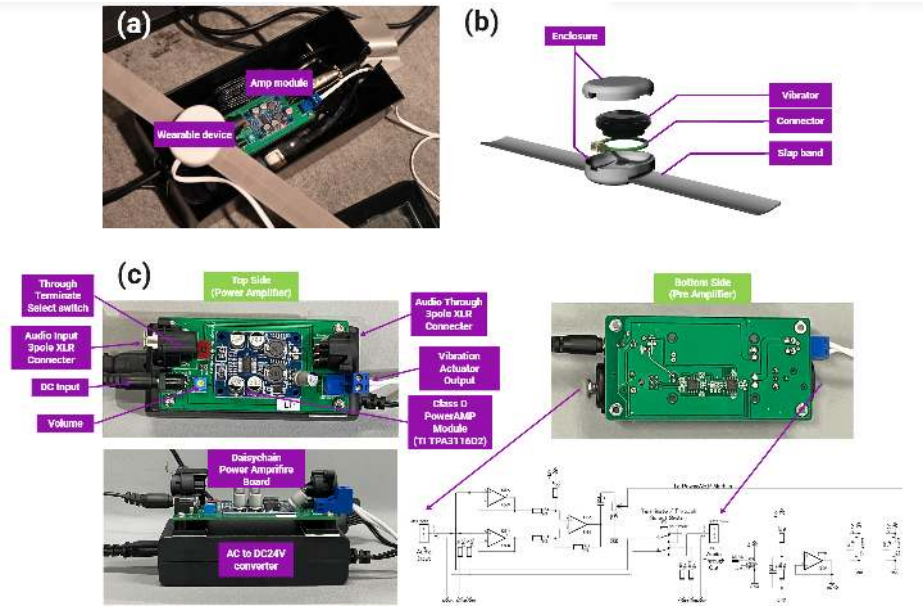

Fig. 3. Technical details of the haptic wearable system including (a) An overview photo of the haptic device setup for each participant, (b) 3D model of the wearable device, (c) Technical architecture of the Haptic Amp Module.

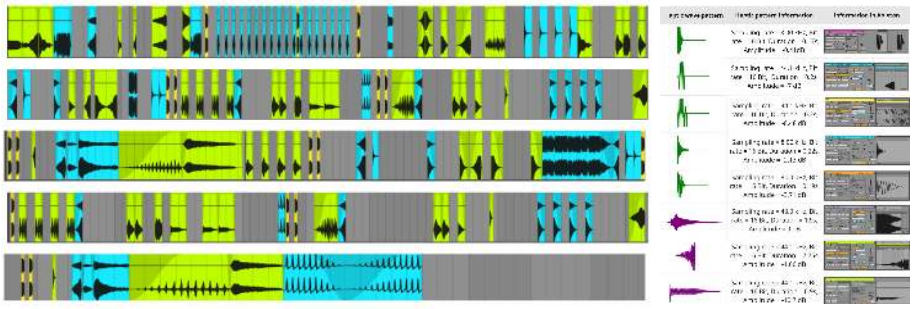

Fig. 4. Left: Haptic design in fully choreographed dance section. Right: Examples of haptic pattern profile in Ableton

to other traditional forms of dance. In this performance, about 30% of the dance movements were predetermined (e.g., within a certain number of beats, the dancers need to move from one side of the stage to the other, but when and how to move was not decided). In line with the dance movements, we incorporated fully choreographed haptic sections and improvisational haptic sections into the performance. Here, we describe the haptic choreography of the dance performance in detail:

Scene 1 (8 minutes). Four dancers entered the scene through a 2m*2m*2m semi-closed white box, another dancer imitated the four dancers' movement from the outside. The four dancers pushed the box towards the outsider until they were covered by the white box. The haptic feedback of this scene was fully improvisational. *Sine waves* was the basic pattern that was used. We adjusted *sine wave* with variations in intensity to mirror the dancers' subtle shifts and sways. We applied short sensations when the dancers executed strong full-body movements like falling or striking.

Scene 2 (6 minutes). In the first half of the scene, dancers tried to eliminate each other, and two were able to escape. In the second half, one dancer was locked inside the box, and others acted mechanically around. One dancer then drove everyone else into the box. The imprisoned dancers put up an active dance inside the box. The last active dance part in the second half of this scene was fully choreographed (see Figure 4).

Scene 3 (4 minutes). In this scene, one dancer lied on the ground and held the box on their abdomen, then gently rotated it. When they could not hold it anymore, the others came and supported to hold the box. This scene was fully improvisational. We applied subtle *sine waves* to reflect the rotation of the white box.

Scene 4 (6 minutes). In this scene, four dancers performed mirror-symmetric movements in two pairs, and tried to touch each other in reflection. This scene was fully improvisational, and free from music or rhythm. The dancers described this scene with metaphors related to the feeling of vibrancy in contrast to the previous scenes. Therefore, haptic patterns converted from audio file of water running or raining sound were used, whose parameters and intensities were manually adjusted in the live performance.

Scene 5 (6 minutes). In the first half, the dancers alternated several times between predetermined dance movements and improvisational dance segments. In the end, four dancers went back into the white box, and the last dancer closed the box. This scene includes a combination of fully choreographed haptic sections and improvisational haptic sections for the first part of the scene. At the end, random haptic patterns were applied to enhance the intense feeling that the performance has reached its climax rather than reflecting on any physical movements.

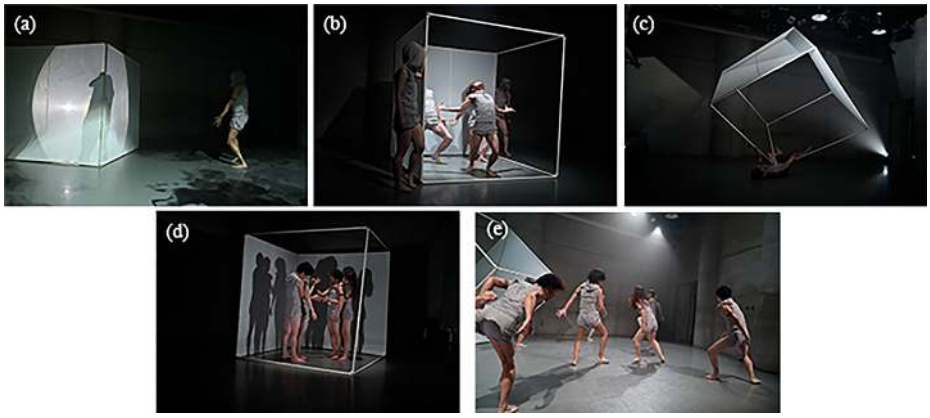

Fig. 5. Performance scenes. (a) Scene 1. (b) Scene 2. (c) Scene 3. (d) Scene 4. (e) Scene 5.

4 Evaluating Audience Expectations in a Public Stage

4.1 Method

Questionnaire Design We applied a within-subject approach to collect participants' subjective evaluations after watching the dance performance using the questionnaire. Previous works leveraged audience satisfaction to evaluate the efficacy of dance performances [19], and audience satisfaction towards the performance is shown to be affected by audience expectations [25] because expectation drives rational behaviour [4]. Inspired by these findings, we designed a study to evaluate audience satisfaction by measuring whether audience expectations towards the performance were met. We utilised the AAEI [21], an empirically validated scale [32], to measure the audience's experience related to their expectations. We modified the statements from previous investigation [32] to measure whether the probing items met the audience's expectations on three elements of AAEI.

Hypotheses We constructed a priori hypotheses that our dance performance can achieve its proposed functionality of delivering haptic feedback to the audiences, and therefore is effective in inducing satisfying viewing experience on the emotional and cognitive levels. We constructed three hypotheses as follows:

- *H1*: The proposed dance performance meets the audience's expectation of a haptic-installed dance performance. (Authenticity)
- *H2*: The haptic-installed dance performance increases the audience's sense of engagement. (Collective-Engagement)
- *H3*: The haptic-installed dance performance enables the audience's to acquire new knowledge. (Knowledge)

4.2 Participants and Procedure

We received valid responses from 131 participants (seventy-eight female, forty-nine male, four unknown; average age = 43.08 years old, SD = 16.77 years old). Participants were professional dancers (5), amateur dancers with learning experience (50), and people with no experience in dancing (70). Participants' dance performance viewing experience was several times a month (50), once a month (25), several times a year (39), and never before (11).

The dance performance was staged three times in the same theatre in June 2023. Before each show, one staff member introduced the concept of the performance and the device on the stage. The audience gave informed consent on paper to this IRB-approved research before the show began. Participants watched the 30-minute show, and then answered the questionnaire.

4.3 Quantitative Results

We analysed our questionnaire responses in SPSS (see Table 1). Shapiro-Wilk tests were performed to check normality. We report descriptive statistics, as well as the results of Wilcoxon Signed Ranks Tests with p-value and effect size which indicates the statistical significance of the participants' fulfilled expectations. We used the baseline score (3) as hypothesised median for the Wilcoxon tests.

Hypothesise	Statement	Mean (SD)	Significance
H1	*Q1*: The haptic dance performance experience met my expectations and I was very satisfied.	3.85 (0.968)	Z(129)=-7.169, p<0.01***,d=-0.628
H2	*Q2*: The tactile stimulation made me feel a greater sense of presence than I usually watch a dance performance.	3.56 (1.121)	Z(129)=-4.814, p<0.01***,d=-0.421
H2	*Q3*: I felt a connection to the dancers through the haptic device.	3.39 (1.117)	Z(129)=-3.520, p<0.01***,d=-0.308
H3	*Q4*: I felt that the tactile stimuli presented were consistent with the dancer's performative somatic information. (Note: Please answer by whether the timing matched the dancers' body movements, instead of the music)	3.67 (0.999)	Z(129)=-6.148, p<0.01***,d=-0.536
H3	*Q5*: The haptic dance performance gave me new insights and inspiration about dance performance compared to the other performances I watched before.	3.49 (0.998)	Z(129)=-4.741, p<0.01***,d=-0.414

Table 1. Summary of the Hypotheses, Questions, and Quantitative Results.

5 Discussion

In our work, we designed the new role of the haptic DJ bearing resemblance to that of the lighting designer in stage performances. Much like a lighting designer cues specific

lighting effects to complement the choreography, the haptic DJ is responsible for timing and delivering the designed haptic patterns aligned with the dance movements in real-time. However, our work is specific to one contemporary dance piece with 5 male dancers, while a larger sample size and different dance genres would provide deeper insights into design and technology preferences.

Our audience expectation data suggests that overall the audience members were generally satisfied by the haptic-enabled viewing experience. For example, an increased sense of presence and the feeling of closer distance with the dancers were reported. The haptic sensation also provided them with enjoyable and multi-dimensional information to inspire their thinking and imagination. However, we did not compare their viewing experience without the haptic experience, or measure objective data such as the audience's biological data. A potential future direction is to conduct a comparison study between with haptic and without haptic audience viewing experience.

6 Conclusions

We proposed a haptic-installed contemporary dance performance with a new improvisational figure, the haptic DJ. During the public dance performance, we found that the haptic experience was well-received and earned overall positive feedback from the audience. The results we gathered are indicative of the possibility of using improvisational haptic feedback to connect the performers and audiences in the entertainment industry. We hope this study can encourage and assist future development in using haptic technology in live performance and installation settings.

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