

Feeling the Crowd: Translating K-pop Audience Reactions into Haptic Feedback for Immersive Concert Experiences

Hyojin Kim

Graduate School of Culture Technology
KAIST

Daejeon, Republic of Korea
mayzel99@kaist.ac.kr

Gaeun Kim

Graduate School of Culture Technology
KAIST

Daejeon, Republic of Korea
gaeunkim@kaist.ac.kr

Juhan Nam

Graduate School of Culture Technology
KAIST

Daejeon, Republic of Korea
juhan.nam@kaist.ac.kr

Kyung Myun Lee

School of Digital Humanities and Computational Social Sciences
KAIST

Daejeon, Republic of Korea
kmlee2@kaist.ac.kr

Abstract—Concert experiences are shaped not only by music, but also by collective audience reactions such as cheering, fan chants, and applause. These reactions contribute to the shared energy and social atmosphere of live performances. However, in online and virtual concert experiences, the collective atmosphere of the crowd may not be fully conveyed to viewers. Prior music haptic systems have primarily focused on communicating musical information, such as rhythm or beat. In this project, we explore how auditory audience reactions in K-pop concerts can be translated into body-based haptic feedback. We developed a prototype using a K-pop live performance video and a body-based haptic suit. The system consists of three haptic layers: cheering sounds, fan chants, and musical beats. We manually annotated cheering and fan-chant segments to identify the timing of audience reactions. Cheering intensity was derived from RMS-based energy variations, fan-chant pitch contours were mapped to four vertical motor zones, and kick and snare events were rendered as rhythmic haptic pulses. We conducted a pilot study with 10 participants, comparing a Beat Only condition with an Audience Reaction condition and examining participant preferences through a haptic-adjustment phase and interviews. Participants reported higher perceived audience energy, co-presence, social connectedness, immersion, and overall experience in the Audience Reaction condition than in the Beat Only condition, although participants did not always interpret all haptic layers as explicit audience cues. This work presents an initial exploration of haptics for conveying collective audience atmosphere and enriching multisensory concert-viewing experiences, while offering design directions for future virtual concert environments.

Index Terms—Haptic Feedback, Audience Reactions, K-pop Concerts, Multisensory Interaction, Concert Experience

I. INTRODUCTION

Concert experiences are shaped not only by music itself, but also by collective audience reactions. Audiences cheer, become emotionally moved, and experience the social atmosphere of the venue together with others. Such collective experiences

play an important role in shaping the overall concert experience [1]. This characteristic is particularly amplified in K-pop concerts, which are often marked by highly collective and enthusiastic fan cultures [2]. Therefore, audience reactions constitute a central element of concert experiences rather than merely background sound.

However, virtual concerts can make these collective audience experiences more difficult to perceive. Virtual concerts enable audiences to experience digital performances without being constrained by physical distance, often through platforms such as virtual reality and the metaverse [3]. Although these formats allow viewers to enjoy performances from anywhere, physical separation and limited social cues can make it difficult to fully convey the presence, reactions, and collective energy of other audience members [4].

One promising approach for addressing this limitation is to extend virtual concert experiences beyond visual and auditory modalities. Compared with in-person concerts, virtual concerts often rely primarily on visual and auditory cues and provide more limited opportunities for bodily and multisensory engagement [3], [5]. Accordingly, prior research has explored haptic feedback to enrich music and virtual concert experiences [5].

However, haptic systems for music experiences have primarily focused on conveying musical information, such as rhythm, pitch, or loudness. Relatively little work has explored how haptic feedback can convey audience reactions as embodied social cues in virtual concert experiences. This presents an opportunity to extend music haptics beyond musical information toward communicating the collective energy and social atmosphere of live audiences.

In this study, we explore how sound-based audience reactions in K-pop concert videos can be translated into layered

haptic feedback. We designed a system that renders cheering sounds, fan chants, and musical beats as distinct haptic layers. We further conducted a pilot study to examine how audience-reaction haptics influence concert-viewing experiences, how participants interpret individual haptic layers, and how these layers may be adapted to different user preferences. Based on these findings, we discuss the potential of audience-reaction haptics as an embodied social layer for future virtual concerts and musical metaverse environments.

II. RELATED WORKS

A. *Haptics for Music and Concert Experiences*

Recent reviews have documented a growing body of musical haptics systems that translate musical information, such as rhythm, pitch, timbre, and higher-level affective attributes, into tactile stimulation for music enrichment or sensory substitution [6], [7]. These systems have been deployed in personal listening, live performance, and XR settings.

For example, Turchet et al. explicitly explored wearable haptics for live music audiences, proposing that music-related tactile stimulation and participatory interaction can augment concert experiences [8]. Venkatesan and Wang discussed the potential benefits of haptic feedback in virtual reality (VR) concerts and reported that haptic music feedback can contribute to positive concert experiences, including social presence-related outcomes [5]. More recently, researchers have explored conveying multiple musical elements through audio decomposition [9], as well as providing tactile representations of music through wristband-based systems for home listening [10].

However, the source signals in most musical haptics systems are derived primarily from the music itself. While some work has explored performer gestures, physiological signals, or performer-generated cues in live settings, collective audience reactions remain comparatively underexplored as a distinct haptic source. Our work extends musical haptics toward this social layer of concert experience by rendering cheering and fan chants as temporally structured audience signals, alongside rhythmic musical cues.

B. *Audience Reactions in Mediated Concert Experiences*

Audience reactions are not merely background elements of a concert; they make the collective energy, emotional intensity, and social atmosphere of a performance perceptible. Prior work has shown that the social dimension of concert attendance contributes meaningfully to audience enjoyment and the overall live music experience [2], [11], [12].

Human-Computer Interaction (HCI) researchers have explored how audience reactions can enrich mediated concert experiences by making the presence and activity of other viewers perceptible. For example, Lee et al. analyzed audience interactions in live concerts and translated them into collective avatar reactions for a VR K-pop concert, showing how audience feedback can support socially connected virtual concert experiences [13]. Beyond virtual concert settings, He et al. explored the real-time detection and sharing of

audience members' aesthetic chills during in-person music performances, while Huang et al. examined the sharing of frisson among online video viewers [14], [15]. These studies demonstrate the potential of shared audience responses to convey collective affect and connection across co-located and remote media experiences.

However, prior work has primarily represented audience responses through visual, avatar-based, or physiological feedback. In contrast, our study examines auditory audience reactions in K-pop concert videos, including cheering and fan chants, as temporally structured collective signals. These reactions are embedded in the acoustic environment of live concerts and can reveal when and how the crowd collectively responds to a performance. Rather than presenting these reactions through an additional visual channel, we translate them into body-based haptic feedback. This approach may allow perceived audience energy and social atmosphere to be experienced through a sensory channel separate from the music audio, potentially reducing interference with listening while making collective reactions more bodily perceptible.

III. DESIGNING HAPTIC REPRESENTATIONS OF AUDIENCE REACTIONS

Figure 1 presents the overall pipeline of our system. The timestamped audience-reaction segments, together with the concert audio, were used to extract reaction-specific features and generate three haptic layers: cheering, fan chant, and beat. The resulting haptic events were synchronized with the video and rendered through a bHaptics TactSuit Pro, a wearable vest with 32 vibrotactile motors distributed across the front and back of the torso. We differentiated the three layers through their motor locations, activation areas, vibration intensities, and temporal patterns.

A. *Selection of Audience Reactions for Haptic Rendering*

In this study, audience reactions refer to the collective expressions produced by audiences in response to the music and performers during a concert. Lee et al. categorized audience reactions in K-pop concerts into movement-based and sound-based reactions, and further divided sound-based reactions into cheering and sing-along [13]. This classification suggests that sound-based audience participation in K-pop concerts primarily takes two forms: spontaneous and emotional cheering and organized participation synchronized with the music.

Based on this distinction, we selected cheering sounds and fan chants as the two representative audience reactions to be translated into haptic feedback. Cheering sounds convey the energy and emotional atmosphere of the concert venue, whereas fan chants represent collective participation synchronized with the music. Because these two audience reactions communicate different types of information, they were designed as independent haptic layers.

Because cheering and fan chants occur only at specific moments, we additionally included a beat layer to provide minimal rhythmic context throughout the performance. Rather

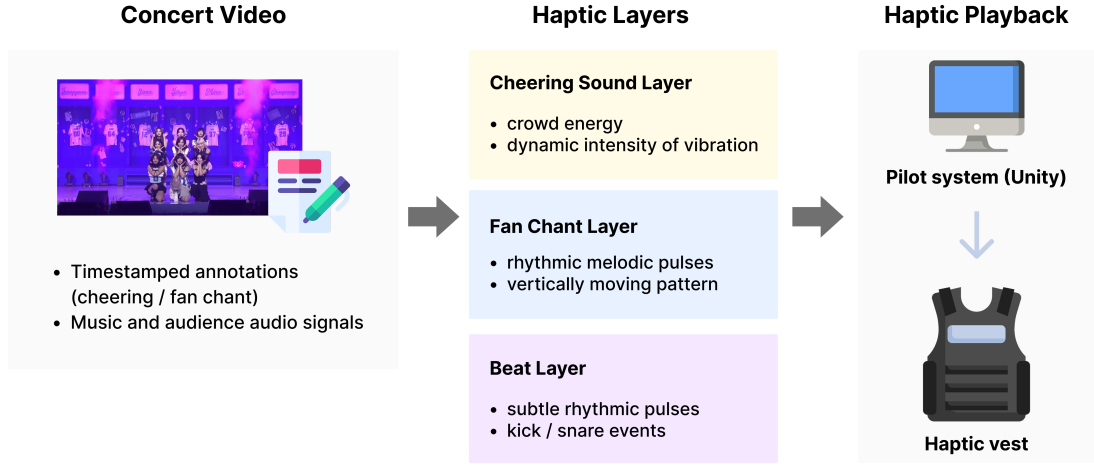


Fig. 1. System overview.

than serving as a primary source of audience information, the beat layer supports the interpretation of cheering and fan chants by situating them within the ongoing musical flow.

B. Layered Haptic Design

The three layers were differentiated through their motor locations, activation areas, vibration intensities, and temporal patterns. Figure 2 illustrates the motor configurations used for the cheering sound, fan-chant, and beat layers.

1) *Cheering Sound Layer:* Cheering sounds are non-verbal audience responses such as shouting, cheering, and exclamations that most directly represent the energy and atmosphere of a concert. During performance highlights or interactions between the artist and the audience, the intensity of cheering continuously changes over time, reflecting both the excitement of the audience and the overall atmosphere of the venue.

To capture these changes, we treated the overall acoustic energy of each cheering segment as an indicator of crowd intensity. We extracted the root-mean-square (RMS) amplitude envelope, which summarizes how the energy of the cheering audio changes over time. Higher RMS values were treated as indicating moments more likely to include louder or denser audience responses. The normalized RMS values were then mapped to the vibration intensity of the haptic motors.

The cheering layer used global intensity levels to vary the number and location of activated motors. High-intensity cheering activated 16 motors across the central front and back of the vest, medium-intensity cheering activated 8 motors, and low-intensity cheering activated 4 motors on the back. This configuration was designed to make stronger crowd responses feel more spatially expansive and intense.

2) *Fan Chant Layer:* Fan chants are a representative form of organized audience participation in K-pop fandom culture. Following predefined fan-chant guidelines, audiences collectively chant member names, lyrics, or short phrases at designated moments during a performance. Unlike cheering sounds, fan chants are synchronized with the music and contain both rhythmic and melodic structures. As such, they

play an important role in facilitating interactions between the audience and the performer.

To preserve these musical characteristics, we extracted the vocal stem from each fan chant segment and converted it into MIDI format. The resulting pitch contour was mapped to four vertically arranged motor zones on the front of the haptic vest, corresponding to progressively higher pitch ranges. Restricting the layer to the front of the vest differentiated fan chants from the other haptic layers, while the vertical mapping enabled users to perceive melodic movement as spatial haptic motion. This design was inspired by prior work suggesting that spatial vibration cues can support the perception of melodic information [7].

3) *Beat Layer:* The beat layer was generated by first separating the drum stem using Demucs [16], followed by extracting kick and snare events. Direct kick detection from the separated drum stem was unstable because of interference from other percussion instruments. We therefore estimated kick events using the beat grid obtained through beat tracking, whereas snare events were identified through onset detection.

To facilitate perceptual separation, kick and snare events were assigned to different spatial locations on the vest. Kick events were rendered on the lower back to evoke a heavier, bass-like sensation, whereas snare events were presented at a higher back location using short, sharp vibrations.

C. Prototype Implementation

To instantiate the proposed haptic design in a concert-viewing context, we developed a pilot system using a selected K-pop concert video.

We selected the concert video according to three criteria: (1) cheering sounds and fan chants had to be clearly distinguishable, (2) interactions between the artist and the audience had to be sufficiently represented, and (3) the song had to be familiar to a general audience. Based on these criteria, we selected a 2024 concert performance by TWICE, a well-known K-pop girl group.¹

¹<https://youtu.be/8tgs9Oq-7a4?si=w2oq0tGitLcdeSs9>

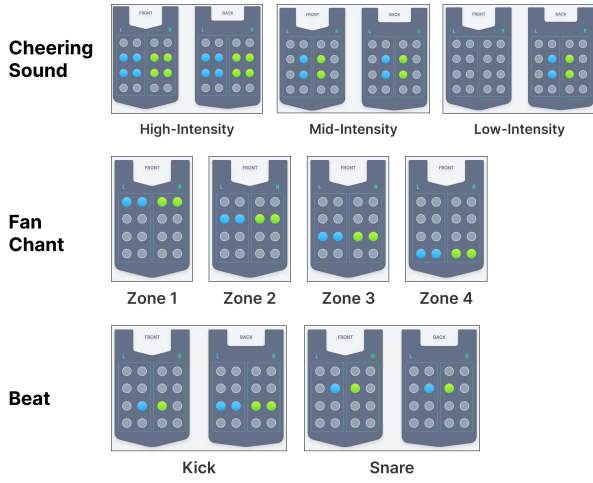


Fig. 2. Motor configurations for the three haptic layers: cheering sounds, fan chants, and beats.

We then manually annotated the onset and offset of cheering sounds and fan chants in the video. Audience reactions often overlap with music and artist vocals, while fan chants contain both social and musical information, making reliable detection using signal processing alone difficult. The resulting timestamps were used to define the temporal boundaries of audience-reaction segments for subsequent haptic generation.

IV. PILOT STUDY

We conducted a pilot study to investigate how audience-reaction haptic feedback influences concert-video viewing experiences. Rather than providing a definitive quantitative evaluation of system performance, the study aimed to examine how haptic cues representing audience presence, collective energy, and concert atmosphere shape users' subjective experiences. We further explored participants' preferences for different haptic layers and their expectations for future haptic interfaces in virtual concert environments.

A. Study design

The study consisted of a condition-comparison phase, followed by a haptic-adjustment phase and a semi-structured interview. To examine the additional contribution of audience-reaction haptics beyond conventional music haptics, participants experienced both the *Beat Only* and *Audience Reaction* conditions during the condition-comparison phase and completed a questionnaire after each condition. In the *Beat Only* condition, participants received haptic feedback from the beat layer only. In the *Audience Reaction* condition, participants received the same beat-based haptic feedback together with additional audience-reaction layers representing cheering sounds and fan chants. Using the identical beat layer in both conditions ensured that the underlying music-based haptic feedback remained constant, allowing us to examine participants' responses to the addition of the audience-reaction layers.

After completing the condition-comparison phase, participants proceeded to the haptic-adjustment phase. They were provided with an interface that allowed them to adjust the activation and intensity of each haptic layer. They were asked to freely modify the layers to create what they considered to be the most effective concert experience for "feeling together with the audience." This phase was intended to explore individual differences in haptic preferences and adjustment strategies, informing future design considerations for audience-reaction haptic systems.

B. Participants and Procedure

We recruited 10 participants (6 female and 4 male) aged 23 to 36 years ($M = 27.30$, $SD = 3.68$). The study began with an explanation of the research objectives and experimental procedure, followed by informed consent. Before the main experiment, participants completed a pre-study questionnaire that collected demographic information and background characteristics related to haptic feedback and concert-viewing experiences.

Participants then wore the haptic suit and watched the same approximately three-minute K-pop concert video under two haptic conditions: *Beat Only* and *Audience Reaction*. The order of conditions was counterbalanced to reduce potential order effects. After each condition, participants completed a questionnaire evaluating their experience.

After completing the condition-comparison phase, participants proceeded to the haptic-adjustment phase. Following this phase, we conducted a semi-structured interview. Participants were asked about the criteria they used when adjusting the haptic layers, which configurations most effectively conveyed concert atmosphere and perceived audience energy, and how direct control over haptic feedback influenced their overall experience. They were also asked about additional features they would want in future systems.

C. Measures

The questionnaire was organized into five categories: immersion, co-presence, social connectedness, perceived audience energy, and overall experience.

Immersion was assessed using seven selected items adapted from the Immersive Experience Questionnaire (IEQ) [17], and *co-presence* was assessed using four selected items adapted from the co-presence subscale of the Networked Minds Social Presence Inventory (NMSPI) [18]. These items were selected and adapted to assess participants' immersion in the concert-viewing experience and their perceived co-presence with the concert audience. Immersion was rated on a five-point Likert scale, whereas co-presence was rated on a seven-point Likert scale. The selected questionnaire items are presented in Table I.

Social connectedness was measured using the Inclusion of Other in the Self (IOS) scale [19], a widely used single-item measure of perceived interpersonal closeness. Participants selected one of seven diagrams representing their perceived closeness to the audience shown in the concert video. Although

Exploratory Study (N=10)

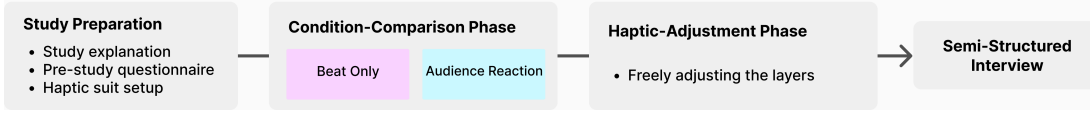


Fig. 3. Pilot study procedure.

TABLE I
SELECTED AND ADAPTED QUESTIONNAIRE ITEMS FOR IMMERSION AND CO-PRESENCE.

Item	Questionnaire statement
Immersion (IEQ; 5-point Likert scale)	
I1	The concert captured my attention.
I2	I felt focused on the concert.
I3	I lost track of time.
I4	I felt that I was interacting with the concert environment.
I5	I felt separated from my real-world environment.
I6	I felt that the concert was something I was experiencing, rather than something I was just watching.
I7	My sense of being at the concert venue was stronger than my sense of being in the real world.
Co-presence (NMSPI; 7-point Likert scale)	
C1	I felt as if the audience and I were together at the same concert venue.
C2	I was often aware of the audience's presence while watching the concert.
C3	I hardly noticed the audience's presence while watching the concert. (R)
C4	I felt as if the audience and I were in different places rather than together at the same concert venue. (R)

Note. IEQ = Immersive Experience Questionnaire; NMSPI = Networked Minds Social Presence Inventory. (R) indicates reverse-coded items.

IOS and the NMSPI co-presence items are conceptually related, they were analyzed separately because they capture different aspects of audience-related experience: co-presence reflects the perceived sense of sharing a space with others, whereas IOS reflects perceived psychological closeness.

In addition to the established questionnaires, we included two study-specific measures to assess perceived audience energy and overall concert-viewing experience. These measures were designed to capture participants' subjective impressions rather than to assess validated psychological constructs. *Perceived audience energy* was assessed using a single item measuring the extent to which participants felt that the haptic feedback effectively conveyed the energy and atmosphere of the concert audience. *Overall experience* was assessed using three items addressing perceived improvement in the viewing experience, overall satisfaction, and intention for future use. Both measures used five-point Likert scales, and responses to these three items were averaged to obtain an overall experience score.

D. Data Analysis

1) *Quantitative Analysis*: To examine the effect of audience-reaction haptic layers, we conducted within-subject comparisons between the *Beat Only* and *Audience Reaction* conditions across five questionnaire categories: immersion, co-presence, social connectedness, perceived audience energy, and overall experience. Given the small sample size ($N = 10$) and the ordinal nature of the rating data, we used Wilcoxon signed-rank tests.

Given the exploratory nature of the study, statistical results were interpreted as indicative response patterns rather than definitive hypothesis-testing outcomes. To complement the scale-level analysis, we examined participant-level changes to assess whether condition differences were consistently observed across individuals. For each participant, we calculated the within-participant difference as follows:

$$\Delta_i = \text{Audience Reaction score}_i - \text{Beat Only score}_i$$

2) *Qualitative Analysis*: We conducted lightweight thematic coding of the post-study interview responses to contextualize the quantitative findings. Two researchers reviewed the responses and examined and refined descriptive codes, iteratively grouping them into higher-level patterns related to participants' interpretations of audience-reaction haptics, perceptions of individual haptic layers, and preferences for haptic personalization. We also examined observations from the haptic-adjustment phase alongside the interview data to further understand participants' preferences and interpretations.

E. Findings

1) *Higher Experience Ratings, but Not Always as Social Cues*: Figure 4 compares participants' ratings between the *Beat Only* and *Audience Reaction* conditions, while also visualizing participant-level changes across conditions. Wilcoxon signed-rank tests revealed significantly higher ratings in the Audience Reaction condition across all five measured dimensions: co-presence ($M = 4.85$ vs. 2.38 , $p = .002$), social connectedness ($M = 5.00$ vs. 2.30 , $p = .002$), perceived

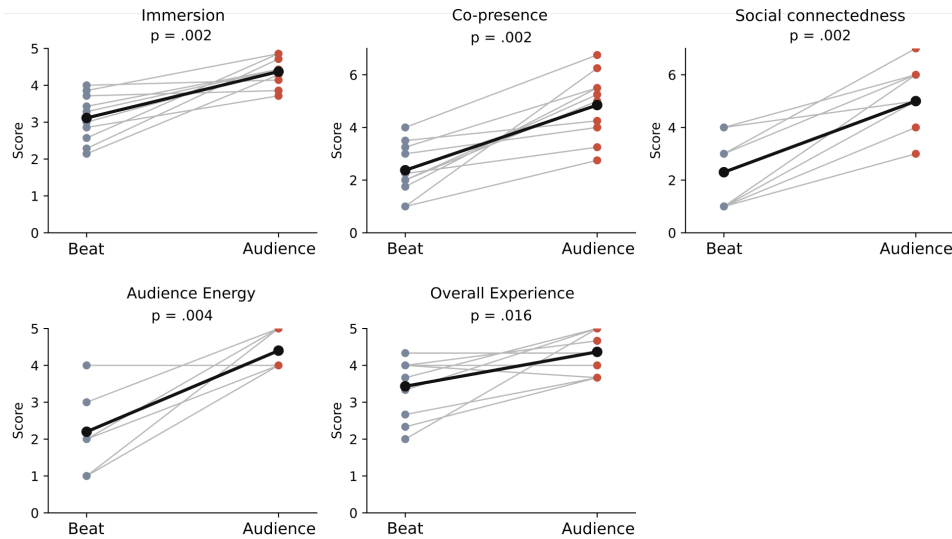


Fig. 4. Mean ratings for immersion, co-presence, social connectedness, perceived audience energy, and overall experience across the Beat Only and Audience Reaction conditions. Thin lines represent individual participants, and thick black lines indicate mean ratings.

audience energy ($M = 4.40$ vs. 2.20 , $p = .0039$), immersion ($M = 4.37$ vs. 3.11 , $p = .002$), and overall concert-viewing experience ($M = 4.37$ vs. 3.43 , $p = .0156$).

The participant-level trajectories further showed that these aggregate differences were largely consistent across individuals. All 10 participants reported higher immersion, co-presence, and social connectedness in the *Audience Reaction* condition. Perceived audience energy also increased for 9 out of 10 participants. In contrast, ratings of overall experience showed greater individual variation: several participants reported little difference between conditions or a slight decrease in the *Audience Reaction* condition.

Interview responses, however, revealed a more nuanced interpretation of these effects. Although participants reported that the addition of audience haptic layers, including cheering sounds and fan chants, enhanced the energy and sense of presence of the concert, these layers were not always explicitly recognized as representations of audience reactions. Instead, some participants interpreted them primarily as making the haptic experience richer, stronger, and more dynamic.

For example, H05 explained:

“I liked it when the audience layer was added, and it increased immersion. But I think it was less because I felt the audience and more because the vibrations became more dynamic and richer.”

Similarly, H04 noted:

“Immersion improved, but rather than recognizing the audience, it felt more like enjoying the performance together in a fun way.”

These responses suggest that, although the audience-reaction haptic layers were intended to convey the presence of other audience members, they may also have functioned more broadly as a way of enriching the sensory intensity and energy associated with a concert environment. In other words, the

positive evaluations of the *Audience Reaction* condition may not have resulted solely from the social meaning of audience reactions, but also from the increased richness and dynamism of the haptic stimulation itself.

2) *Participants Interpreted Individual Haptic Layers Differently*: We further examined participants’ perceptions of each haptic layer through the interview data.

The **cheering sound layer** was the clearest layer for conveying a sense of concert atmosphere and audience presence. Participants primarily associated this layer with collective cheering, the energy of the crowd, and the feeling of being at a live concert.

“It reminded me of the excitement I feel when everyone cheers together at a concert venue.” (H10)

However, because the cheering sound layer often reflected sustained crowd cheers, it was typically delivered with relatively strong and prolonged vibrations. Several participants found these sensations tiring or overwhelming. Overall, the cheering sound layer appeared to convey collective audience presence more clearly than the fan chant layer, but its duration and intensity need to be carefully calibrated to maintain comfort and satisfaction.

The **fan chant layer** was generally perceived as dynamic and entertaining, but it was often interpreted more as a musical effect than as an audience reaction. Participants explained that, because the layer followed the melodic structure of the song, it felt less like the sound of a crowd and more like a haptic effect emphasizing salient musical moments.

“I came to think of the fan chant not so much as an audience reaction, but as a highlight or point in the music.” (H05)

Some participants also noted that the fan chants were not clearly audible in the concert video, making it more difficult to identify the haptic pattern as an audience-related cue.

In addition, participants expressed mixed reactions to the spatial mapping of the fan chant layer, which was rendered through front motors. Some participants found it unfamiliar or awkward to experience audience-related vibrations on the front of the body, as vibrations rarely originate from that direction in everyday life.

Taken together, the fan chant layer was effective in providing a more varied and engaging haptic experience, but its social meaning as an audience cue was conveyed relatively weakly. Future designs may need to improve its alignment with the audio and reconsider the spatial mapping used to represent fan chants.

The *beat layer* was primarily perceived as a musical foundation that conveyed the bodily resonance of loud sound at a concert venue or enabled participants to physically feel the rhythm of the music.

“The beat conveyed the feeling of my body resonating because the sound is so loud at a concert.” (H01)

“You need to feel the beat well to get excited. It felt like having powerful speakers.” (H08)

Participants expressed mixed preferences regarding the intensity and repetitiveness of the beat layer. Participants who prioritized feeling the music tended to increase the beat intensity during the haptic-adjustment phase. In contrast, others found the continuously repeated beat sensations distracting. However, even these participants did not suggest removing the beat layer entirely. Rather, they considered a subtle beat layer, similar to the default setting, helpful for sustaining musical immersion without becoming intrusive.

These findings suggest that the beat layer should remain as a musical foundation, while being calibrated to avoid excessive repetition or intensity. Allowing users to adjust its intensity may be an appropriate way to accommodate different preferences.

3) *The Need for Bounded Personalization*: Interview findings revealed substantial individual differences in preferred haptic intensity, the relative prominence of different layers, and the priority participants placed on musical versus audience-related information. During the haptic-adjustment phase, some participants increased the beat layer to better feel the music, whereas others increased the cheering sound layer to strengthen the atmosphere of the concert venue. In contrast, several participants substantially reduced the cheering sound layer because they found it tiring or overwhelming.

These differences suggest that personalization is important not only because users vary in tactile sensitivity, but also because they differ in how they listen to music and what they want from a concert-viewing experience. All 10 participants expressed that a haptic-adjustment function would be valuable if the system were deployed in practice. Some participants also wanted greater control beyond intensity, such as adjusting motor locations (H02, H05, H09) or modifying the intensity of individual segments (H06). At the same time, participants raised concerns that allowing users to adjust too many parameters could introduce unnecessary cognitive load.

These findings suggest that future systems should provide bounded personalization rather than fully open-ended haptic editing. For example, systems could offer controls for overall intensity, the relative balance between music-based and audience-reaction layers, and a small set of spatial presets for motor placement.

V. LIMITATIONS AND FUTURE DIRECTIONS

A. Limitations

This study has several limitations. First, the two experimental conditions differed not only in the presence of audience-reaction haptics but also in the amount, intensity, and variety of haptic stimulation. Therefore, the observed differences cannot be attributed solely to the social meaning of audience reactions. Future studies should include a control condition with comparable haptic intensity, duration, and spatial distribution to better isolate the contribution of audience-related information.

Second, this pilot study involved only ten participants and a single concert video from one K-pop group, limiting the generalizability of our findings across different audiences and performance contexts. Future evaluations should include larger and more diverse participant samples and a broader range of concert stimuli.

Finally, our evaluation relied primarily on self-reported measures, including study-specific ratings of perceived audience energy and overall experience. Future research could incorporate additional behavioral or physiological measures to complement self-reports and provide a more comprehensive understanding of audience-reaction haptics.

B. Future Directions of Audience-Reaction Haptics for Virtual Concerts

While the present system was evaluated with pre-recorded concert videos and pre-authored haptic patterns, our findings point to several opportunities for extending audience-reaction haptics to future virtual concerts and musical metaverse environments. Recent work has shown that music experiences in Social VR already span diverse platforms, event formats, and community practices [20]. In such settings, users may find it difficult to perceive the presence and reactions of other audience members despite sharing the same virtual space in real time. Audience-reaction haptics could help communicate the dynamic presence of remote audience members.

First, **future systems could derive haptic feedback from real-time collective audience signals**. Rather than directly transmitting each individual’s reaction, platforms could aggregate temporally aligned signals such as chat activity, avatar movement, or controller inputs, extending prior approaches that translate collective audience activity into mediated concert feedback [13], [21]. The density, synchrony, and intensity of these reactions could then be mapped to crowd-level haptic events, allowing viewers to feel moments when the audience collectively responds to a performance. Such aggregation may help preserve the sense of collective energy while avoiding

overwhelming users with excessive or fragmented individual feedback.

Second, **audience-reaction haptics may become more socially interpretable when they are grounded in multimodal and spatial context.** Our findings showed that certain haptic layers, particularly the fan chant layer, were not always recognized as audience-related cues. In virtual concert environments, these cues could be aligned with visible avatar behaviors, such as cheering, clapping, waving light sticks, or coordinated fan gestures, building on prior work that has represented collective audience activity through avatars and other multimodal social cues [13], [22]. Connecting haptic events to observable audience actions may help users understand not only that a reaction is occurring, but also where it is situated, and what kind of collective event it represents.

Third, **future virtual concert platforms should support bounded and context-sensitive personalization.** Viewers may differ in whether they prioritize musical detail, crowd atmosphere, or a lower-stimulation viewing experience [21], [23]. Rather than requiring users to edit individual haptic events, systems could provide a small number of meaningful controls, such as overall haptic intensity, the balance between music-based and audience-reaction feedback, and presets for different modes of participation. For example, a music-focused mode could foreground beat-based feedback, whereas a crowd-immersion mode could emphasize collective cheering and fan-response cues.

Finally, **audience-reaction haptics may also offer opportunities to support accessible concert experiences for Deaf and Hard-of-Hearing (DHH) audiences.** While existing music-haptic systems have primarily focused on conveying musical information [6], representing collective audience reactions through haptics could provide an additional channel for perceiving the social atmosphere of a concert. Future research could explore how audience-reaction haptics can be designed and personalized in collaboration with DHH users to accommodate diverse sensory needs and preferences.

Taken together, these directions suggest that audience-reaction haptics could serve as an embodied social layer for virtual concerts. By combining real-time collective signals, multimodal grounding, and bounded personalization, future systems may help remote viewers experience not only the music itself, but also the shared energy of participating in a concert with others, while opening new opportunities for accessible concert experiences.

VI. CONCLUSION

This work explored how audience reactions in K-pop concerts can be translated into layered haptic feedback to enrich concert-viewing experiences. We designed and evaluated a system that rendered cheering sounds, fan chants, and musical beats through distinct haptic layers.

In our pilot evaluation, participants reported higher perceived co-presence, social connectedness, perceived audience energy, immersion, and overall experience in the Audience Reaction condition than in the Beat Only condition. At the same

time, participants did not always interpret the added haptic layers as explicit audience cues, highlighting the importance of socially meaningful multimodal grounding and bounded personalization.

Our findings suggest that audience-reaction haptics can extend music haptics beyond rhythm or audio augmentation, offering an embodied social layer that may help future virtual concerts and musical metaverse environments convey the shared energy of live audiences.

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