# "Contradiction pushes me to improvise": Performer Expressivity and Engagement in Distanced Movement Performance Paradigms

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The virtualization of traditionally in-person experiences has altered the workflows of performing arts communities, resulting in modifications to performance venues and alterations to expressiveness and interaction. 25 professional movement-based performers who have participated in both live and online performances were interviewed in order to determine how virtualization processes affected their practices and how they adapted to these changes. We discovered that performers viewed online performances as time-limited, non-interactive film recordings. Instead of avoiding distant venues, performers adapted to new limitations, inventing improvisation strategies in distracting environments and using time and technological constraints as creative constraints. To investigate how a distanced paradigm affects the live-action workflow of dancers, we staged a performance in which a dancer interacted with a robot in a remote location. The case study demonstrated that the performer modified her rehearsal techniques to work with remote technology and adapted to live interaction with a remote audience by visualizing unseen interactions. This study provides guidance for the design of interactive technology for virtual performances, taking into account the adaptation strategies that performers are currently employing to circumvent limitations of time, location, and absence.

CCS Concepts: • **Applied computing → Performing arts**; • **Human-centered computing → Empirical studies in collaborative and social computing**.

Additional Key Words and Phrases: performance technology, dance improvisation, remote robotics

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## 1 INTRODUCTION

Restrictions on gatherings have increased the performing arts' reliance on online media,[59], while artistic expression has turned to technologies that provide more connected experiences for

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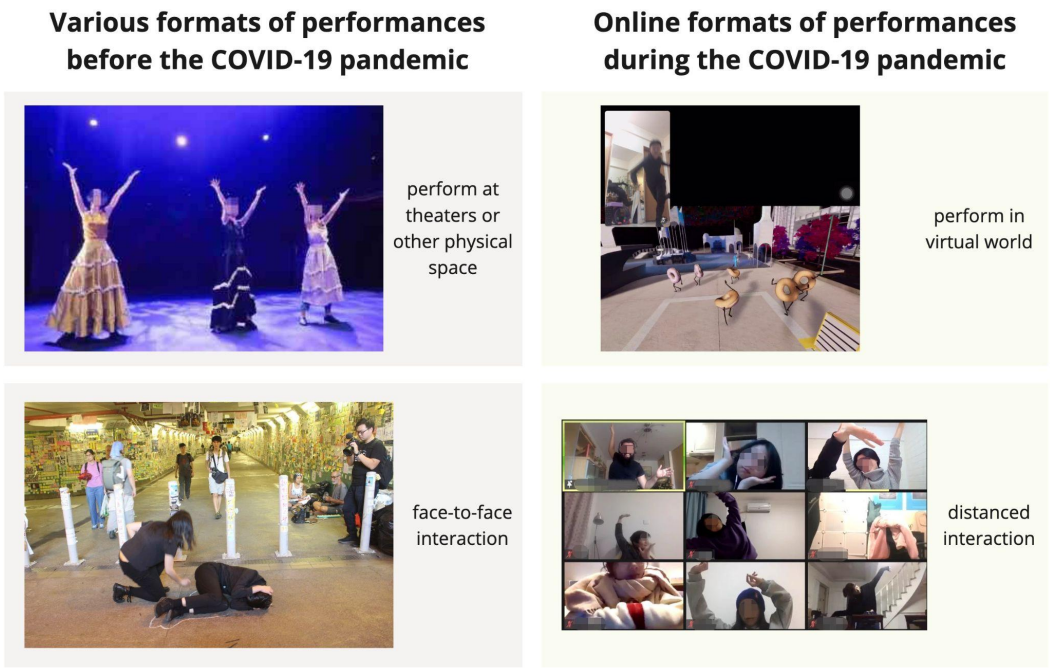


Fig. 1. Summary of shifts in artistic performances before and during the COVID-19 pandemic restrictions, with selected figures showing the particular performers interviewed in this study.**(Upper Left)** Performing live in a local theater with reduced audiences during COVID-19 (P16). **(Upper Right)** Live performance in a virtual environment with other dancers using motion capture (P10), **(Bottom Left)** A conceptual performance with live audiences in a socially distant format during the COVID-19 lockdown (P23). **(Bottom Right)** Online performance workshop conducted in Zoom during the COVID-19 lockdown (P13).

performers and audiences. Zoom, Twitch, Instagram, and web-based formats have been utilized by musicians and dancers as online venues [40, 46].

Collaborative theatrical performances have always relied on live presence, which is more difficult to achieve and measure in a virtual setting[39]. Recent research has investigated how presence is enacted in distributed performances utilizing focused attention and visualized audience feedback, [60], as well as multi-sensory and immersive technologies for enhanced subjective presence [39]. However, the recent COVID-19 lockdown imposed new restrictions and requirements on performers attempting such distributed interventions. This is especially important during prolonged pandemic response scenarios and their associated mental challenges in China, Hong Kong, and nearby Eastern Asian cultures [28], which have traditionally placed a significant emphasis on stage performance [52]. How are the workflows and perceptions of these performers altered by virtualized paradigms?

This study examines how the pandemic has affected the movement-based performance community in China and Hong Kong in terms of expressiveness and participation in distant performance paradigms. We conducted semi-structured interviews with professional performers to determine how the pandemic affected their performance techniques. We discovered that technology reshaped online performance by dictating how the performance was presented and how performers could interact with the audience. Performers viewed these obstacles as new creative constraints, but the absence of physical contact and the feeling of being observed resulted in less engaging experiences for both performers and audiences.

Our research focuses on the design and analysis of collaborative performance community systems and technologies. We created a remote performance that allows the performer to interact with a robot in a remote performance venue in order to study the performer's workflow and interpretation during a real, live remote performance. The Japanese performer operated the robot remotely with a restricted field of vision. This enables us to investigate how a purely remote performance format influences how a performer perceives interacting with a remote robotic arm during rehearsal and production.

Our study applied an interview-based qualitative approach and a performance case study to address the following:

**RQ1**: How has emergence of online performances caused by mandatory isolation impacted performers' practices?

**RQ2**: What improvisation and engagement strategies are performers using to interact with audiences remotely?

**RQ3**: What can the process of undertaking a remote performance tell us about performer and audience expectations in working with remote-performance technologies?

## 2 BACKGROUND

### 2.1 COVID-19's Impact on the Performance Arts

Studies of the social effects of the recent lockdown found that social isolation and loneliness led to negative changes in people's emotions, behavior, and cognitive functions [23]. These destructive effects are especially pronounced for artists whose work relies on the human body. [57]. In addition, performance formats have changed in performing arts communities as a result of COVID-19 [27]. Social distancing has led to the cancellation and decline of physical art performance venues, and artistic performances increasingly rely on online platforms [51, 58]. In response to the restrictions imposed following the pandemic, a variety of artistic mediums were investigated. [3]. Artists in the performing arts experienced disruptions to their daily lives and creative routines, compelling them to actively develop new strategies and technologies to adapt to the new norm [9].

Since COVID-19, the evolution of performance has impacted both the audience and the performer. The interactions and visual experiences of performance artists in their spaces are complex, requiring physical interaction with the audience and environment [43]. In the virtual format, the performer's workflow can be modified to accommodate the reduced engagement, resulting in a new audience perception. Replacing the physical stage with a video chat interface blurs the performer's and audience's identities [6], creating new challenges for the performer to comprehend audience reactions in a less engaging format.

Despite these limitations, the performing arts can enhance online collaborative interactions between individuals [41]. Online creative activities can enhance interpersonal communication and connection and mitigate the negative effects of social isolation. Specifically, social dance interventions can improve participants' body awareness and sense of self, according to [50]. Moreover, distanced performance strategies permit the manipulation of the show's background, allowing creative interventions that place performances in particular contexts to leverage immersive technologies to situate the performance more easily than constructing the stage background for physical performance [56] .

### 2.2 Interactive Technologies and Strategies for Audience Engagement

Priority is placed on audience participation in performance production [14]. The integration of emerging digital technologies and live performances improves the connections and interactions between performers and audiences. In addition, mixed design strategies have been implemented to

engage audiences in interactive performances [11] so that audiences can better comprehend complex, layered conceptual works created for them [24]. This has included work in immersive engaged performances in the social space [4, 19], as well as robotics for expressive actions [35] during performative paradigms [30, 49]. Applying these performance technologies in dance performance, however, burdens the choreography and production process because more rehearsal time is required to incorporate interactive technologies into dance performance [29].

Recent research has concentrated on the application of interactive or reactive multimedia to dance performance and production. Motion capture has created digital interactions between audiences and performers. [25]. This has led to the creation of interactive dance works utilizing live motion capture systems, [1, 16, 25], which generates fine movement data for subsequent analyses [25]. Other research has investigated the application of digital technology in virtual dance, using VR and motion capture technology to create immersive experiences that enable audience engagement with dance performances from different points of view, thereby creating a sense of tension. [63].

Movement improvisation is a sub-field of dance research in which interactive technologies have been implemented [8, 44, 53]. Despite the fact that all live performances involve improvisational artistry, technologies introduce uncertainty and new challenges to the production of live performances because performers can adapt their movements to the performing environment [8]. For instance, the interactive system "Choreography" was used to investigate the effect of avatar characteristics of motion capture on movement improvisation [44]. Humans are frequently unaware of how technologies may be interpreted [31]; therefore, dancers must employ strategies to manage openness in improvisation [45]. As demonstrated, improvisation is essential to human collaborative processes due to their dynamic and error-reflective nature, [26], making it essential for computer-mediated movement communication.

### 2.3 Dance and Movement Research in HCI

A significant amount of HCI research has centered on how participants can engage in movement-based interactions utilizing immersive and collaborative technologies. One study analyzed the tension between dancers and participants in an interactive movement installation [61], discovering that dance performance can encourage participants to actively engage with the interactive installation by using their body movements to control the screen display to create a collaborative dance performance. A study using the Radical Choreographic Object (RCO) to investigate audiences' participation in dance performances through gesture-based interactions found that participants shift from obeying it to re-interpreting and re-appropriating it [2]. Such interactions can also occur in virtual reality, where dance communities can remotely express themselves [42]. Other aspects of the dance production process have also been explored, including a web-based collaborative tool for connecting choreographers for dance production [10], long-term technology-mediated learning of dance-related processes such as the use of physical instruments[48], decomposition of movements sequences [47], and movement-based communication in remote partnering [38].

Regarding interaction with audiences, prior research conducted before the pandemic found that performers frequently miss audience feedback in the distributed performance format due to the increased demands on the performer's attention, which has implications for the design of hybrid spaces containing both physical and virtual interactions [60]. This is comparable to the case of group Zoom exercises classes, which shared the difficulties of a lack of interactive feedback and demanding attention [21], which may be expected to occur in the format of a remote performance. However, the collaborative nature of the latter may result in adaptations distinct from learning processes. Within the context of live streaming in China, it was discovered that audience and performer interaction occurs in a center-surround orientation, with audiences contributing

interaction via instant messaging[34]. This indicates that audiences can play an active role in online performance experiences created for performers and viewers.

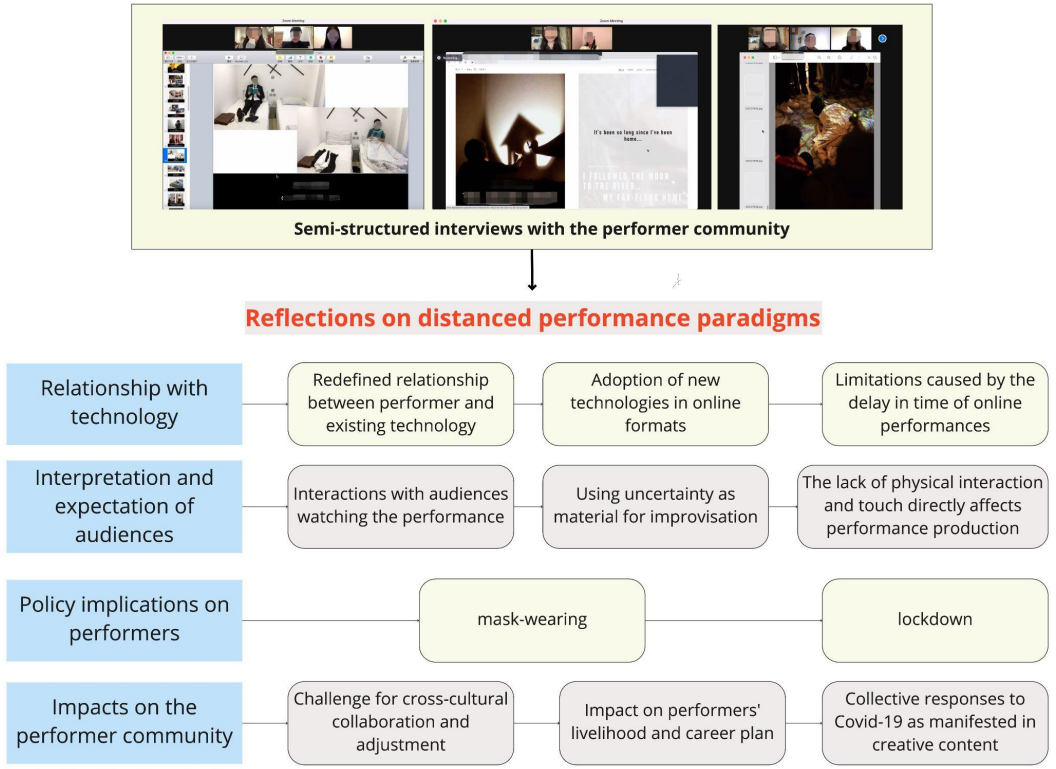


Fig. 2. Research methodology and key findings. **(Top)** Screen captures from semi-structured interviews conducted in Zoom, **(Bottom)** Diagramming the key findings.

## 3 METHODS

### 3.1 Data Acquisition and Analysis

Semi-structured interviews were conducted with 25 experienced performers via Zoom (14), Tencent Meet (3), and in-person to examine performer expressiveness and engagement and the performer-audience relationship in distanced performances (8). There were four classical performers (ballet and opera), four contemporary dancers, two practitioners of Chinese traditional dance, three social dancers (swing and Latin), and three actors among these performers1. Three of the four performers engaged in the artistic practice of behavioral performance in the tradition of Marina Abramović were dance instructors, while the other two were primarily involved in online performances.

In Hong Kong and China, seasoned performers were recruited with varied backgrounds in various movement-based arts. Only interviewees who had participated in at least one online (or otherwise socially distant through technology) performance during the COVID-19 pandemic were selected, in addition to at least two live performances throughout their careers (frequently up to 10 or more). During the interviewing process, institutional research protocols were approved and strictly adhered to. Performers were recruited for the study through direct messages and social media posts

(WeChat, WhatsApp, Instagram). Each interview lasted thirty to forty-five minutes. The interviews were conducted and recorded in English or Chinese. The Chinese interviews were transcribed into English after removing any identifying information and personal details. 25 individuals (3 men and 22 women) were interviewed (Table 1). When physically available, seven performers were interviewed in person[55].

### 3.2 Interview Procedure

In each semi-structured interview, participants were requested to briefly describe their artistic practice and performance experiences. The interviews then included questions about their experience performing online, the effect of shifts caused by social distancing on their practice, their perspectives on how people are performing during quarantine periods, the distinction between conducting performances online and in a physical location, and how they expressed themselves in online performance.

### 3.3 Data Collection and Analysis

Open coding was utilized to conduct a thematic analysis of the interview transcripts. One researcher took notes and transcribed the data during the interviews. Based on the transcription of the interview discussion, the potential codes were derived [54]. Two researchers independently classified the interviews into the previously obtained codes, which were then categorized into themes. Following categorization, the three researchers analyzed the themes collectively for presentation purposes.

Table 1. Summary of interviewees' information

| ID | Gender | Occupation | Area of Practice | Online Tech/Approach Mentioned |
|---|---|---|---|---|
| P1 | F | Performer | cantonese opera, performance tech | video, Zoom, streaming |
| P2 | F | Dancer | Chinese dance, ballet | distanced live, streaming, youtube, bilibili |
| P3 | F | Dancer | professional dance practice | distanced live, youtube |
| P4 | F | Performer | dance instructor | Zoom, distanced live, commercial online performance |
| P5 | M | Dancer | modern dance | video, distanced live, social media platforms, online courses |
| P6 | F | Dancer | classical dance, dance instructor | Zoom, distanced live, teaching dance on social media |
| P7 | F | Performer | performance art. dance teacher | video, Zoom, distanced live, online teaching, youtube |
| P8 | F | Performer | Chinese dance | video, virtual platforms |
| P9 | F | Performer | participatory performance | distanced live, Zoom |
| P10 | F | Performer | ballroom dance, virtual dance tech | VR, virtual platforms, Zoom, motion capture, AR |
| P11 | M | Performer | performance art, behavioral art | performance recording, Zoom, distanced live, streaming |
| P12 | F | Dancer | ballet, latin | audience engagement, distanced live, streaming |
| P13 | F | Performer | theatre, applied drama | Zoom, online workshop, distanced live performance |
| P14 | F | Dancer | contemporary dance | video, VR, distanced live, motion capture, streaming |
| P15 | F | Performer | theatrical performance | distanced live, online workshop |
| P16 | F | Performer | musical theater | video, youtube, streaming |
| P17 | F | Dancer | Chinese dance | online workshop, video |
| P18 | M | Dancer | swing dance performance | video, online workshop, streaming |
| P19 | F | Dancer | swing dance performance | video, online workshop, distanced performance |
| P20 | F | Performer | contemporary dance | video, distanced performance, Zoom |
| P21 | F | Performer | live performance, performance art | distanced live, social media platforms, streaming |
| P22 | F | Performer | performance art, behavioral art | VR, 360 and immersive methods, video, virtual platforms |
| P23 | F | Performer | online performance | distanced live, Zoom, online teaching, youtube |
| P24 | F | Dancer | performance art, dance teaching | video, Zoom, distanced live, virtual, bilibili, youtube |
| P25 | F | Dancer | contemporary dance, teaching | distanced live, Zoom teaching |

## 4 RESULTS

The interviews conducted with performers revealed four ways in which distanced performance affected them: adaptation to technologies for remote communication, change in performers' perceptions of audiences, adaptation to policy measures on distance, and changes in the community of practice with regard to content and collaboration.

### 4.1 Performer's Relationship with Technology

*4.1.1 Redefined relationship between performer and existing technology.* According to the interviewed professional performers, webcam-based platforms such as YouTube and Zoom host the majority of online performances. The asynchronous nature of both conducting streamed performances on virtual platforms and being recorded in film shoots (e.g., P4, P10, P18, P19, P22, and P25) was highlighted by interviewees: "Online performance is comparable to film-making; we only need to satisfy the director because there are no other audience members in our respective spaces. Therefore, greater control is required, and there is less energy than in live performances " (P4). The interviewees agreed that in the absence of an audience in their performance space, the Zoom window functions as a camera with a limited field of view, similar to a film camera on a movie set. Thus, they were less willing to perform in front of an audience as in live theater and instead adhered to the "multiple takes" film-making model (P10).

Due to these limitations, performers adopted novel technologies like web broadcasts (P18, P19) and video recording (P22). "Due to the epidemic, I had some inspiration and started to apply film-making skills into my work, including the use of cameras and perspectives" (P24). Performing in Zoom requires performers to serve as movie directors performing in front of the camera for the film (P3, P10, P23, P24), and they can do recordings repeatedly in multiple takes until satisfactory (P18, P19), unlike live performances.

However, performers also indicated that video recording capabilities applied to distanced performances also have space limitations since rooms and the perspectives of cameras limited their movements. "I cannot do a full range of movements in the small studio I stream from, and cameras cannot pick up my movements when I'm on the ground" (P23). Performers are often reluctant to take up purely online work (P14, P21, P22), noting the limits on their expressivity: "The recording is not the actual work because I have presence and intuition in my own live work" (P11).

The online performance pushed participants to rethink their relationship with audiences and how technology enables the relationship: "We're closer to rethinking what technology is in our lives and also how we as human beings as a species should carry on" (P5). They can directly see the audience in live performances, and "my attention was primarily on human behaviors and reactions" (P2). In the online context, the performance is represented through an abstraction layer instead of being directly watched. P1 notes that the "Zoom meeting setting defines who we are" and how performance is presented. They "became more intimate with technical devices," namely the camera, and "less intimate with audiences" (P1). Once the camera becomes the only medium that connects the performers and the audiences, "it dominates the performance" as well: "The camera determines the perspective of the audience, and the space that I can dance is also limited" (P3).

In contrast, another participant felt there were no significant differences in performance between online and offline, but "the quality of performance in terms of detail differs in the live show and online performance." (P4). One performer incorporated remote texting into her performance practice, creating a work that uses audience texting to add interactivity to her work and overcome the lack of intimacy in online performance (P9).

In summary, we found that professional performers perceived the observing lens of online performance as less intimate and more dominating than live performances, where audiences are individuated, but have since begun adapting to virtualization technology.

*4.1.2 Adoption of new technologies in online formats.* In addition to adopting online streaming and video recording, some performers also took up entirely new media previously unexplored in their practice (P4, P6, P11, P15, P18, P19, and P22). For example, a performer who works with live behavioral concept performances was pushed to experiment with interactive video: "I decided to move to the opposite medium from my work to challenge myself in these times" (P22). She also noted the extreme differences between the media, noting that in live performances, audiences can move around and see what they'd like from various perspectives. Still, in the new medium of video, "the audience cannot control the director's decisions, so I end up having additional power to frame what audiences experience" (P22).

The online meeting format encourages this framing as a way for performers to creatively limit what audiences can see, contrary to live performance, in which the audience chooses what they want to see. In reaction, P22 has explored the use of 360 video to let audiences see a more immersive view of the performance, recognizing that even immersive perspectives cannot substitute for a live setting: "Going to a venue has an association with quality experience due to expectation and commitment by the audience; this cannot be shown in an immersive manner" (P22).

In one case, the performer participated in a live performance at a distance (Fig. 3b) that was disseminated online on a website. To show the trial-and-error process behind the experiments the performer was doing to realize the performance, the website used a scheduled live-view window that is shared with visitors. In this way, the performing artist can show his process virtually as a proxy for showing the actual live performance itself: "Showing the process together with the other artists was for me the performance itself; it is not the same as my performance, but it is something completely different" (P11). In his case, he adapted to the lack of live audiences: "To myself, no matter if there is an audience present, I already know the situation and mental state I want to be in and am not aware of the audience directly." Thus, this transition to an online static format can potentially be made more accessible by the type of mental framing in P11.

As opposed to simply adapting to the online format, certain performers have also explored innovations in performance technology as part of their renewed focus or practice (P1, P7, P10, P21, and P24). For example, despite beginning her career in ballroom and contemporary practices, P10 has spent the duration of the pandemic era on technological performances, working with motion capture, dancing with recorded video in VR, avatar dancing, virtual performance using Tilt Brush in VR, etc. "I see COVID as an opportunity for innovation, doing things that I didn't' get to explore before" (P10). A case in point is her last work to be proposed for live performance, which was interrupted by the COVID-19 outbreak. In that piece, 16 people were to be stuck in a square space, viewable by the audience from above. When that work had to be moved online in video format, she was initially distraught: "Looking from above is only one viewpoint live, but ironically, it was much more immersive than the many viewpoints of the movie." However, in looking for ways of overcoming the limitations of single-viewpoints in a video, she became absorbed in immersive, distanced performances. In particular, she has adapted to the online format, figuring out how to "monitor how everyone moves" when rehearsing in Zoom and multitasking to manage the spaces of everyone who participates" in online works. She finds her previous experience as a movie director especially helpful in this new online regime and often asks her students and dancers to imagine the scenario to "design the perspective-taking process" for immersive works. She has understood the advantages of online performance, such as being able to situate the performance in a place that is more related to the topic than the theater could be (dancing next to a lake as part of the story


Fig. 3. Dance practices of professional performers engaged during the interview. Photos used with permission. (a) Live performance in virtual environment using motion capture. Other dancers and audiences are in the virtual venue. **(P10)** (b) Performing at a distance with others for a live feed on a website used for online exhibition. Other dancers are in person; audiences are online. **(P11)** (c) Online theater conducted in Zoom, with audiences on Zoom and other performers offline sharing physical space. **(P13)** (d) Online performance workshop conducted in Zoom. Performers are distanced from each other physically. **(P15)** (e) Live performance with reduced audiences. Other performers share the stage, audiences watch in person and online. **(P16)** (f) A human-robot remote-distanced performance in Zoom. The performer and robot are located 12 hours apart; limited audiences in person. **(P20)** (g) A distanced performance where audience members text the artist via the Signal app while she is going to sleep at a distanced venue. Audiences are in person but not in the space of the performer. **(P21)** (h) Live behavioral performance documented using 360 videos during the lockdown. Limited audiences in person, no other performers. **(P22)** (i) Online performance related to self-isolation in hotels and home quarantine. The performer is on her own in a room while audiences watch online. **(P23)** (j) A online dance film produced during lockdown. Performance with other collaborators in-person, but the film is shared with online audiences asynchronously. **(P24)** (k) A virtual online performance conducted in Zoom. The two performers are in two cities but share the same Zoom screen. The live image of the second performer is projected onto the first performer's physical space, and the first performer's live view is shared with audiences online via Zoom and online. Both performers and audiences are in separate physical spaces. **(P24)** (l) A streamed live performance. Other performers in-person, audiences watch live online. **(P25)**

as opposed to an artificial lake in live theater, for example) and running the performance at any feasible time without fixed venues. In short, she has taken distanced performance as an emerging and integrated part of her practice.

The same can be said of P24, who, up until COVID-19, was teaching and performing contemporary and pair dance. Since the pandemic lockdown, she has been doing online performances and online residencies exclusively, with one work that uses projection and puppet play on a layered Zoom screen to show collaborative performance with a participant from a different country: “In doing what I want to do for my practice, I have found that there’s always a new way to be creative, so the new constraints are just sources of inspiration for new ways of connecting performers” (P24).

In summary, performers have experimented with new technology that was previously not part of their practice to take advantage of immersiveness and expressivity in distanced work. Some have made these technologies a core part of their practice going forward, creating a community for such practice.

*4.1.3 Limitations caused by the delay in the time of online performances.* Participants used the notion of "time delay" to describe both the technical and personal changes brought about by online performances. Referring to the video lag on Zoom, P1 notes: "There must be some kind of delay in terms of the technical aspect, so you’re always seeing something different from intended" (P1). When performing online to instruct the students, participants were frequently dissatisfied with the delay in performance (P1, P4, P10, and P23). "It often leads to unsatisfactory teaching results when many students learn the wrong rhythm due to the delay" (P4).

One participant generalized this delay idea to every aspect of delay when dealing with COVID-19 lockdown, including delays in venue openings, delays in developing one’s own practice, etc. She termed this general idea of delay associated with COVID-19 “deferral, or a desire for something to happen eventually” (P1). Instead of seeing “deferral” as a negative element of the lockdown, she took it as an opportunity and "would like to develop it further in [her] later life" (P1). Delays, like "deferral," can shift current occurrences to later moments in a performance or postpone a scheduled show in an artist’s career. Deferral becomes a metaphor reflecting the performer’s emotional state. It prompts artists to explore how frustration can be transformed into added significance (P1). The temporal deferral of online performances parallels performance practice, where canceled subscriptions and shows occur. The online delay serves as a metaphor for how their lives have changed, altering the way they spend time together. Despite this, the artist sees it as an opportunity to adapt (P1).

The notion of time seems especially relevant in the online world. For one performer, the amount of time available seems especially pressing in formats that require recording and streaming, such as distanced performance. In contrast, live performances do not appear to have such constraints. “Acting in movies and online only lasts briefly, but live performances can last forever” (P21). She equates the current online performance with her previous experience as an actress, noting that both involve time constraints, such as when her part of the stream ends or the director says "cut". On the other hand, the “timelessness of the performance” is reflected in her live works during COVID-19, for example, when she created an 8-hour performance where visitors could visit her in a cage and freely make eye contact. Further illustrating this contrast, she notes that “live performances can be personal because the audience is part of them, but in a movie, who watches it? I cannot tell” (P21). But as the online constraints impose their restrictions, she is looking for ways to adapt: “I continue to search for a performance that lasts forever and is about the self” (P21).

In summary, performers found the delay in the time of online performances to be both a source of hindrance and a constraint that can lead to creative adaptations.

### 4.2 Performer's Interpretation Regarding Audience Interactions

*4.2.1 Interactions with audiences watching the performance.* Online performance redefines how performers interact with audiences. Previously, in live performances, performers were being watched in person by audiences, and they "could immediately get audience feedback" (P2) and "emotional communication" (P3). "This real-time feedback triggers energy in me" (P2). This process created a dialogue loop between the performer and the audience. "When I was doing the live performance, the fact that I was being watched motivated me and energized me. And I enjoy the process of transforming this energy into my dance as a response to the audience" (P2). One performer said, "It was the audience's cheer [in live performance] that really opened up for me to respond through dance patterns" (P8). Another noted that the "interaction with space that the audience occupies" provides the material for one's creative choices (P14).

However, in other instances, the need for audience participation is an adaptation that performance practice in the pandemic era must overcome. For example, despite working exclusively in person for his work before COVID-19, P11 feels that "if [he is] clear about the topic and what [he wants] the outcome to be, not all performance art needs to be for live audiences." He feels he is unaware of the audience because "the topic is more important to the flow." He appears to compartmentalize performances without audiences as "a new thing," but even this type of "showing together is the performance itself" (P11). This perspective also resonates to some extent with the performers who prefer live interaction because they speak of actively trying other methods like video and immersive documentation that do not require audience participation (P21, P22).

In summary, online formats force performers to adopt a single-lens, asynchronous approach toward the audience, creating situations of performing to an abstract viewer (camera lens) instead of the collective interactions found onstage.

*4.2.2 Using uncertainty as material for improvisation.* The capacity to improvise during performances imparts a sense of agency to both the performer and the audience. [8]. Due to the lack of live audience members providing "energy for performance" (P2), online performance creates a situation where "we play to the camera with a previously determined routine" instead of improvising (P4). "Improvising doesn't make sense in the online video because the whole production needs fickle, unpredictable audiences for us to react to" (P18). This is consistent with the view that in online performance, the performer does not have a model of the individual viewer but rather can only focus on a single abstract viewer (such as a webcam or video camera), as we saw in the previous section. Thus, she cannot find ways of improvising with the audience since she cannot know what the audience is feeling "out there" (P6).

Interestingly, we found that performers also take this constraint itself as an opportunity to improvise: "During our live stream, the audience is not ideal [and we] need to refocus, but the contradiction pushes me to improvise; it's like being constantly distracted online" (P1). Meaning, even though performers do not see the audience online well, especially with video-off conference calls, they find the reduced information load to be not necessarily a hindrance but rather a creative constraint. In P1's case, she uses the distractions from random audiences on Zoom as a way to improvise her practice during the performance: "I learned how to distract myself away from the distractions online." The distractions and multitasking required in online performances make it improvisational just to be able to "monitor how everyone is moving and respond to them appropriately" (P10). For (P7), "I'm appreciative of being able to perform in person again," since working in Zoom has been "exhausting because I cannot adapt to my audience." Her practice has been to improvise her participatory performances without rehearsal because she wants to change her actions based on the surprises that audiences bring her. This is only possible in a live space with an engaged audience.

In summary, performers found it difficult to improvise online without the full vision of responsive audiences, but these constraints can serve as creative opportunities to adapt.

*4.2.3 The lack of physical interaction and touch directly affects performance production.* Online performances lack physical interaction between performers and audience members. "The fact that humans cannot touch each other" leads to a lack of "temperature" in the performance experience (P1), meaning there is less energy when the interactions are not physical. "People would come close to look at and touch the makeup on my face after the performance [because] they crave physical connection" (P1). In contrast, when online, "there was always a screen, a separation between the performers and the audiences" (P3). Previously, in live performances, "I often walk into the auditorium and invite the audience to join the dance by taking their hands" (P2). The intimate touch and bodily interaction "is an important part of my performing experience" (P2) that can incentivize the participants to create improvisations and provoke inspiration "for my next choreography creation" (P1).

The lack of touch also impacted the preparation for the performance: "We tried to do online rehearsals with partners from other regions, so there was no physical contact or pulling movement between actors; it was hard to imagine how actors pulled each other in space" (P13). One performer sees herself as a "body researcher" (P5): to perform is "to study your own body through body language and to learn about others' bodies through somatic interaction." (P5). The lack of physical connection would be "a missing part in the process of my art creation" (P6) in the online performing context. However, performers have used even the inability to touch and feel someone's temperature as a creative constraint. (P9) uses emojis and touch-based visual feedback in her text to the audience during the performance to "simulate being touched, not by your hands but by your mind," while P10 experiments with telepresence and motion capture to simulate interaction with remote audiences. P1 notes that even though she cannot feel the audience individually, the rhythm of the audience online as they come and go, turning on and off, gives her a sense of being physically present, like being touched by music.

In summary, physical touch limits online performance, reducing engagement and improvisation. However, this constraint can lead to creative solutions using avenues of communication like sound, touch feedback, and somatics.

### 4.3 Implications of Social Distancing Policies for Performer Practices

*4.3.1 Impact of mask-wearing.* During the pandemic, wearing masks in public places is a mandatory requirement. This makes it difficult for performers to act onstage and interact with audiences. In our interviews, several performers mentioned that "performing with a mask on her face makes her feel a lack of oxygen" (P10) and that "the performer has to take the mask off to breathe frequently" (P25). In addition to the performers' discomfort caused by wearing masks, they also took steps to minimize the impact of wearing a mask on the audience's viewing experience. For example, one performer (P12) wore a transparent mask in her offline performance, even though turning can lead to the mask falling off.

Besides, in performers' eyes, wearing masks not only makes them "look like dead faces" (P10) but also changes the way they sense the audience because audience members are also wearing masks and not showing emotion. The performer cannot see the audience's smile but can only see whether the audience is happy through their eyes. In this case, she "imagines that they are always smiling" (P12). Moreover, one interviewee (P15) said, "In the past, though I could not see all the audience due to lighting reasons, I could still see the first few rows. That created a sense of interaction. Now [online], I feel that the audience is expressionless."

In summary, the government's mandatory requirement on mask-wearing obstructs the performers' presentation of their facial expressions and their perception of the audience's own expressions.

*4.3.2 Impact of the lockdown on performers.* The government's lockdown policy negatively impacted performers' livelihoods. Many performers we interviewed had the experience of scheduled performances being canceled or postponed, negatively affecting their livelihoods (P24, P25). Among the affected performances, some were permanently canceled, while others switched to online formats. "During the pandemic, I don't know when the performance will be suddenly canceled. I would feel sorry that a long-prepared performance cannot be presented in front of the audience (P17)." Moreover, the random nature of these changes makes it difficult for performers to plan their careers around them (P25). In addition, "offline performance exchanges and artistic collaborations between schools have decreased" (P17). Thus, whether the performance is mediated technologically through online or offline means can have consequences for the performers' careers.

One manifestation of the lockdown is particularly strict social distancing mandates in China and Hong Kong: "The number of audiences watching performances offline is strictly limited" (P17). One of our interviewees who teaches dance said, "Before the pandemic, I had 6 to 12 students in one class, which is convenient for students to get to know each other and socialize. But now, under the social-distancing regulation, I can only have one-to-one classes" (P14). There are also psychological impacts of social distancing on performance. For instance, one interviewee mentioned that in her offline performance, "when getting close to the audience, I felt under pressure when I saw one parent holding her small child back from me" (P16). This implies that social distancing has negatively impacted the interaction between performers and the audience, leading to psychological burdens for performers.

On the other hand, we observed some surprisingly positive effects of the lockdown mediated by new technology. For instance, the new online schedules are often asynchronous, meaning that "performances can be done at any time" (P10). Along with the relaxation of time limits, lockdown also "gives one more time to work on oneself and think about how to make technical breakthroughs" (P11). Besides, lockdown provided new social opportunities for performers to "work with friends in small messaging groups to try new things" (P25). Almost half of the performers interviewed mentioned additional time to innovate and refine their practice as an advantage of the pandemic lockdown era (P1, P4, P7, P10, P11, P12, P14, P18, P19, P21, P23, P24, and P25).

In summary, the lockdown reduces performers' offline performance opportunities and practice-based exchanges while enabling them to find time for personal learning.

### 4.4 Impact of Covid-19 on the Performance Community

*4.4.1 Challenges for cross-cultural collaboration and adjustment.* The creative and cultural industries were disrupted by COVID-19 [15], leading to creative solutions using technology to help mitigate these challenges [9]. Several interviewees noted difficulties conducting international collaboration via virtual platforms due to time and location differences: "Due to travel bans, mandatory quarantine, and such policies that limit transnational collaboration, we have no choice but to collaborate online. When we conduct online meetings, I am confused about how to share my thoughts" (P15). Due to the travel limitations imposed, participants had to overcome geographical barriers and rely on virtual platforms to showcase their ideas, but that requires stringent technological requirements. Despite the use of video for communication, it lacked the presence and interaction that characterized live performances (P15).

However, some interviewees with multicultural backgrounds, such as those from overseas studies, noted that COVID-19 also brings new inspirations to distanced collaboration, promoting cross-cultural communication and adjustment: "Everything went online during the pandemic period,

so I had more opportunities and time to contact friends from different countries and cultures online, and then we used video [communication] to create art and performance" (P16). "I did more collaborations with artists from other countries and regions since people had to switch to the online approach, which did not require more effort or time" (P13).

In adapting to distanced performance venues, performers used online, recorded, and immersive strategies: "I was basically dancing by myself amid the pandemic, so I started to consider how to create new work from a different perspective like projection" (P24). P23 even mentioned that performers will still apply such distanced approaches in future performances after COVID-19: "Everyone applied online solutions amid the epidemic, so our community has already adapted to such approaches. Even if the situation improves, we will still use online methods" (P23).

But rather than merely using these new techniques to overcome problems, performers have adapted these strategies as part of their practice going forward, internalizing these interactions into future developments that use these technologies as part of their future performance direction. P23 believed that the performance community will continue to use distanced approaches post-pandemic: "Everyone applied online solutions amid the [lockdown], which leads us to believe that our community has already adapted to such approaches. Even if the situation improves, we will still use such online approaches" (P23).

*4.4.2 Impact on performers' careers and creative content.* Over half of the interviewees noted that they had to stop physical performance and find other outlets like online formats due to the shortage of funds, cancellation of physical performance, and closure of theaters and art organizations: "During the epidemic, the majority of my colleagues changed career directions, and only a few people can persist in them" (P15). They were aware that performing online is more challenging since it is difficult for online audiences to focus on the entire performance and interact with performers via screens: "Online audiences can turn off their screens and drop out of the show at any time, so it is more competitive for artists" (P24). Several performers mentioned that the focus in their career planning transferred from live performance to dance teaching, which can take place online (P2, P4, P7, P14, P18, P19, P24, P23, P25).

The concerns regarding the effects of online shifts in performance venues on creativity[57] were reflected in our interviews, but the participants also noted that they would add personal reflections into their artistic creation and performance themes as responses to COVID-19: "My mental health is very poor amid the pandemic, and there are struggles I want to express through my work" (P24). However, in contrast, P13 mentions that performers may avoid responding to COVID-19 themes due to their negativity: "Theater is an amazing venue since a theater has its own motivation and energy, it will tell you what the audience wants. When we were doing 'Playback Theatre' on the theme of COVID-19, our audiences avoided discussing this topic... From the artist's perspective, we may want to avoid it in online shows too" (P13). "Despite our new [workflows], I personally don't want to mention this since it was painful for me" (P14). Thus, the content of the performer's creations in online formats has also been influenced by their pandemic experience.

## 5 CASE STUDY: A REMOTE PERFORMANCE

While the interviews explored the workflows and expectations of performers, they did not reveal what performers do during a typical online performance. In addition, the interviews were unable to replicate a performer's actual preparation process for dealing with concrete problems using moment-to-moment adaptations to the task during rehearsal and performance. To explore the impact of the performer's expressive abilities and collaboration with a distanced performance system on a live distanced audience, we conducted a Zoom-based performance (Fig. 4). This performance featured a dance artist and a robotic arm in different locations, with a 12-hour time difference. The main

focus was to observe how the performer rehearses and interacts with the remote, autonomously acting robot to engage distant audiences. Additionally, we examined how the performer perceived working with remote-performance technology, and how the audience perceived this technology during the performance (RQ3).

The interviews with performers were unable to address the specific habits and perceptions regarding particular rehearsal and performance actions. Thus, we desired to create a physical remote performance in order to investigate some of the issues alluded to in the interview studies that could not be fully comprehended without a virtual performance. As a result, we hired a dancer from the interviews (P20) to perform on Zoom at 9 a.m. local dancer time, with a robotic arm collaborating with her at 9 p.m. In addition to the physical presence of the robot, the projected image of the dancer is shown to a live audience of 25 at 9 p.m. in a venue where the robot is also physically present. This case study performance focuses on how a dance artist engages in rehearsal and performance processes with a remote robot that she can only see from limited perspectives in order to narrate a story through movement and engage a remote audience.

Fig. 4. A distanced human-robot performance took place at 9 a.m. at the dancer's location and 9 p.m. at the robot's location, with audiences watching offline at the robot's location. **(Left)** Dancer (P20) engaging with the robot arm during rehearsal. **(Middle)** Rehearsal process at the dancer's studio at 9 a.m. and the theater at the same time at 9 p.m. as seen in Zoom. **(Right)** Live performance with the dancer and the remote, choreographed robotic arm dancing together while showing the narrative of the show using movements.

## 5.1 Design and Implementation

*5.1.1 Design rationale based on interview study.* The design of the remote performance was based on interviews with performers about ways to facilitate their expressiveness and collaboration. The previous considerations regarding the lack of improvisation within online venues (P1, P2, P4, P6, P7, etc.) led to the implementation of live audience participation at the location of the robot arm. Because performers shunned the individual Zoom-like audience, we decided to create one large live audience group adhering to social distancing guidelines observed from one camera angle in Zoom by the performers. Due to the performer's lack of a perceptual model of what the audience is experiencing (P6), we decided to minimize the amount of information the performer must multitask with (P1) by creating a single audience as opposed to multiple audiences staring randomly and distractedly at the performer.

Due to the lack of touch and physical presence in remote performances (P1, P3, P5, P9), we decided to employ a robot arm that interacts with the dancer from a distance in our performance. This would provide the dancer with a remote character to choreograph for the performance's plot. Inspired by P2's taking the audience's hand and P10's exploration of virtual interactions, we developed a system that attempts to capture how a performer can engage the audience by

collaborating with a robotic system. We chose an industrial-grade robotic arm because it created the appropriate scale for the in-person interaction while providing ambiguity regarding the robot's identity, which can be interpreted as either an arm or a head in previous studies [32, 33]. Because we wanted to emphasize that the robot is not human, the robot's arm was not designed to perfectly replicate human movements. Rather, it provides the audience with a remote presence that interacts with the performer.

Although the performer cannot interact physically with the audience, the robot arm is present in the space of the live audience. It then creates a narrative with the performer, causing the audience to perceive online and offline elements in the performance. We acknowledge that this robot does not solve the problem with touch sensation. Instead, we engaged with the performer to learn how she might interact with the remote presence system, forming a mental model of how touch-like interactions would occur during rehearsal and performance. For the dancer, we designed the intervention to reduce the performer's impression of dancing in front of a movie camera, as discussed (P1, P21, P22), in favor of collaborative interaction that forces the performer to see what her partner robot is doing in real-time from a limited perspective, and thereby avoiding the "performing for recording" paradigm encountered by the dancer (P10, P11, P22).

Other variables reflect the limitations faced by remote performers, which we did not attempt to design for, but rather wished to reflect in the performance in order to investigate further how the performer can adapt to them. Despite timing difficulties on both rehearsal and performance days, our simultaneous performance in the two remote locations reflected the limitations caused by time delays due to time differences (P1, P4, and P21). In spite of difficulties encountered during rehearsal, the mask-wearing restrictions (P10, P12, P15, and P25) were adhered to during the performance and at the audience locations. Due to the lack of oxygen supply (P10) during exhausting, continuous dance sequences, the mask-wearing dancer was able to take intermittent breaks during the performance. Last but not least, the intervention engages our performer's community, relieving her of the COVID-19 shutdown that occupied her practice, as referenced by those who created new adaptations involving their communities (P13, P15, P16, P22, and P25).

*5.1.2 Implementation and configuration.* We used a Zoom meeting to link the dancer and the performance venue on the main computer in order to implement the performance. The meeting depicts the dancer without her name or toolbars. The main screen is fixed on the dancer, while a small draggable window displays the robot from a frontal view (Fig. 4 Left). A PC connected to a video camera aimed at the robot transmits the live image to the dancer on Zoom. During the performance and rehearsal, the dancer hears the program and microphone audio through Zoom, allowing her to hear the music for the live audience. One laptop controls the robotic arm's movements interactively. Separate laptops connect to the projection system and Zoom, while the primary computer manages the performance. Lighting control includes spotlights on the floor, main lights, front lights sequence, and back-light sequence in the venue.

For this study, we utilized the XArm 6 industrial arm with a gripper (UFactory, Shenzhen). The dance and gesture movements of the robot were programmed by modeling and recording the movements with UFactory Studio, followed by fine-tuning the joint positions with Python code. To create a user interface for controlling each of the robot's movements (Fig. 6), as choreographed by the dancer and director, custom Python code is written. During the performance, the staff is tasked with selecting from a predefined list of possible robot arm gestures via the user interface.

*5.1.3 Narrative structure and choreography.* Figure 5 depicts the performance's plot. In the beginning, the robot and dancer encounter one another. The dancer will make a greeting gesture with the robot and act as though they are meeting a real person; the robot will then respond in kind. The dancer then attempts to teach the robot basic dance steps or gestures. In response to

each gesture, the robot attempts to imitate the step but is unable to do so accurately. The dancer becomes disheartened and exits the stage, while the robot stands and requests assistance from the audience. With the audience's encouragement, the robot begins practicing its movements, gradually enhancing their fluidity.

The dancer returns to the stage on Zoom and dances alone while the robot observes and learns in the subsequent segment. Soon, the dancer and robot will be in sync, performing a choreographed dance to original music. Next, the robot dances independently, combining what he has learned from the human dancer with non-human steps that the human torso cannot imitate. Finally, the dancer aims to regain control over the robot's movements, but the robot starts rebelling. When the dancer tries to teach the robot the original three dance steps, it creates its own moves. Struggling to control it, the dancer disconnects the Zoom connection, which also shuts down the robot, ending the performance.


Fig. 5. Setup diagram for the remote performance. Zoom: for interfacing with the dancer. Main PC: for entering Zoom meetings and the sound output. Video Camera: for capturing the view of the robotic arm to the main PC via HDMI. Laptop 1: for controlling the robot through LAN. Laptop 2: for controlling visual sequence on the floor projection. Audio Mixer: for mixing the sound from the main PC, laptop1, and microphones, so that both Zoom and the audience in the theater can hear sound from both devices. AV Panel: To capture the audio and visual signals and switch the main and floor projection visuals. Light Panel: for controlling the lighting.

## 5.2 Findings

*5.2.1 Performance and rehearsal workflow.* The idea of "deferral" was manifested in how the performance was rehearsed, crossing a 12-hour gap with delays in the video viewing of the robot, causing considerable disturbance for the dancer. Because the dancer could only view the robot head-on, the fixed perspective of the camera eye alluded to in 4.1.1 becomes an inherent limitation on how the performer perceives the performance. Most of the time, she only has a view of the robot with whom she is dancing and not what is happening from the different perspectives of what the robot looks like in 3D. Resonating with previous results: "At the beginning, I had a hard time feeling the robot because there's a distance and a delay; it's the same as communication with

humans; we need time to build up our relationship, but with remote rehearsal, it was much more difficult logistically" (P20).

In terms of improvisation, the dancer left the parts where the robot doesn't follow her movements exactly to be improvised because she "wanted to react to what the robot is doing at the moment." For the part where she pre-choreographed the routine, she said, "I added parts to the choreography during the performance where I had to do the same dance twice," once on her own and once with the robot, "adding on many more elements on the second dance depending on how I feel." However, the improvisation was controlled because the first time she did the movement in the performance, the robot moved poorly, so she could perform any movement artistically. Still, the second time she did the movement, the robot was already good at movement in the story, so she had to improvise something that showed she wanted to control what the robot does. Some of the improvisations are also done by the staff controlling the robot's movement since he is the puppet master who interacts with the dancer directly when the dancer makes a move, showing the robot's personality to the live audience. "The robot was shown not to be a mechanical device but has a personality that I can improvise with" (P20). This finding complements the audience-based improvisation detailed in 4.2.2, where uncertainty lies instead in what the audience does. In contrast, the interaction's uncertainty shows the robot's personality, guiding the performer to improvise based on that uncertainty.

Regarding the rehearsal process, the distanced format made working with the technology difficult due to the limitations in how the robot can be viewed from the perspective of the dancer. "It was difficult because I only had a frontal view of the robot; it was really like brain work rather than physical work: while the robot moves to the left, which joint is rotated, and I have to use my imagination to reflect that on to my own body in terms of which joint should be rotated and which direction I should aim?"

Working with a robotic partner also forces the performer to think about what correspondences there are between human and machine, an essentially imaginative process. "The robot has a completely different body; it doesn't have arms, it doesn't have legs, and it rotates 360 degrees, so I had to imagine how to alternate the robot's joint to my joint because the robot does movements that I never imagined or tried before." Thus, throughout the rehearsal, the performer had to adapt

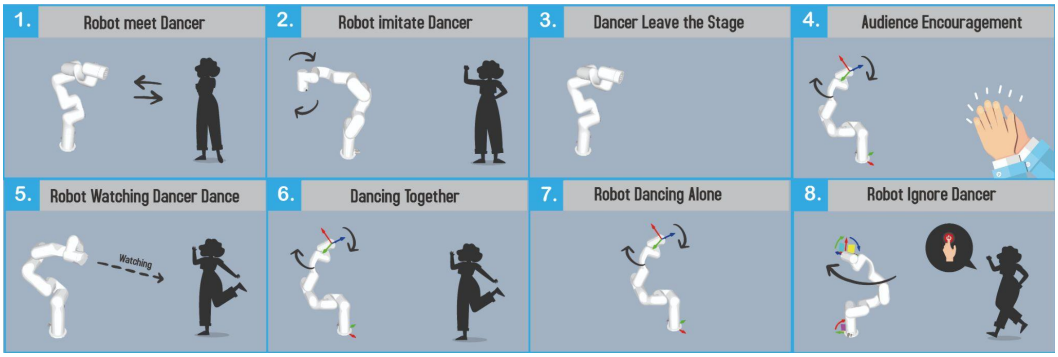


Fig. 6. Storyboard for the remote performance. The robot and the dancer greet each other. The dancer tries to teach the robot how to dance, and the robot tries to imitate it. The dancer feels disappointed that the robot cannot imitate the steps and leaves the stage. The robot asks the audience for encouragement and practices how to dance to become better. The dancer shows the robot how to dance, then dances with the robot on the same song (5 and 6). The robot dances alone with steps that humans find difficult to imitate. The robot ignores the dancer when the dancer tries to control its movements. The frustrated dancer turns off Zoom, which leads to the robot shutting down.

to a new interaction where she danced with a partner who did not move like her. The performer created an interaction that she could not see from the perspective of the audience because she was imitating a non-human form that did not move like her and that she could only see from a single viewpoint. As a result, the audience's perception of that interaction is uncertain.

The cycle is a constant feedback loop: "In the first song, which is my own original choreography, when the robot movements that imitate my moves were shown to me, I began to learn from the robot movements what other things I can do with my body, so when we dance again to the same song, I decided to improvise based on what I saw from the robot... there's an exchange occurring throughout with someone different." These feedback-based interactions are analogous to in-person scenarios when the performer teaches dancing to children, for example: "Teaching the robot is like teaching kids; no one can do exactly what I show them because there are different interpretations by themselves, so it's always impressive to me" (P20).

In summary, due to the constraints of the online format, the performer is forced to use her imagination to collaborate with the robot partner, using mental agility to support the improvisational process.

*5.2.2 Audience evaluation qualitative findings.* Since the performer did not have direct access to the audience while choreographing the robot's movements, we asked the audience directly for their interpretation of the performer's creative intervention (n = 20) to determine whether the performer's expectations and perceptions of the audience experience were consistent with the outcome. Specifically, we investigated how the audience perceived the interaction between the dancer and its independently controlled robot partner. We distributed the questionnaire to twenty members of the audience (n = 20, 12 male, 6 female, and 2 non-binary) after they had witnessed the entire performance. The data was processed, analyzed, and plotted using RStudio. The audience's brief responses to questions regarding their comprehension of the performer-robot interaction were then encoded and analyzed.

Several participants mentioned that the strongest impression during the performance was the interactions between the performer and the remote robot (A7, A10, A11, A14, A15, and A21). Audience members appeared to understand and interpret the movements of the robot based on human emotional interpretations (A4, A10, A11, A13, A16, A18, and A21). For instance, participants assigned emotion to the robot's movements when the performer left the screen: "The robot was sad when the dancer was not happy with it" (A10). Also, participants connected the delayed movements of the robot with the rejection of the performer's leadership; for example, "the robot disdainfully refused to react to the dancer" (A19), "the robot started to give up trying the last dance" (A4), and "the robot seems to have emotions" (A14). However, it is difficult for a few audience members to imagine the robot could have a personality like a human: "It does not have a personality; it just needs to follow the moves of the dancer" (A18). The differences between audiences' perspectives may be due to different understandings of the technologies used: "It looks like they are interacting, but you somehow know that it is programmed" (A11).

In summary, the audience interpreted the actions of the remote robot arm as human and emotionally reactive, providing a narrative that treats both the performer and the robot as equal storytellers in the interaction.

*5.2.3 Audience evaluation survey findings.* The quantitative analysis of the audience survey (n = 20) indicates that the performance was perceived as having a high level of harmony and coherence between dancer and robot movements. Possibly due to the choreographed nature of the sound, the robot's musicality (how well it follows the music) is even greater. In terms of performer-robot interaction, audiences felt the robot should have autonomy during a performance, reflecting the perception of personality and emotion in the robot. They were also adamant that the dancer's

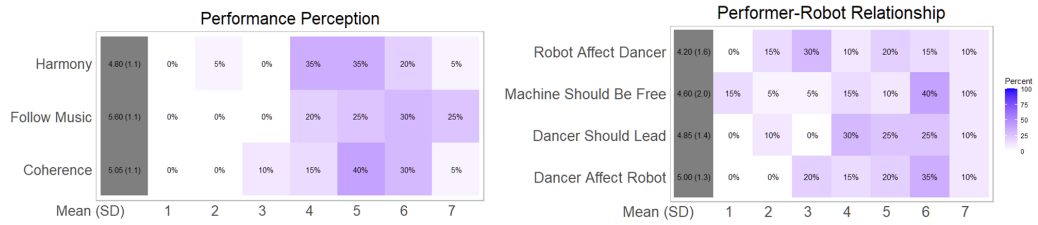


Fig. 7. Audience perception of performance and performer-robot relationship (n=20). Ratings are not significantly different (Coherence vs. Harmony p=0.4206, Coherence vs. Follow Music p=0.1448, Robot Affect Dancer vs. Dancer Affect Robot p=0.1030, Dancer Should Lead vs. Machine Should be Free p=0.9889, Wilcoxon) but for Harmony vs. Follow Music (p=0.0370). Survey questions used: **Harmony** - "How harmonious was the performer and the robot with each other in the dance sequences?" **Follow Music** - "How well did the robot follow the music?" **Coherence** - "How would you rate the amount of coherence in the performer and robot interaction? **Robot Affect Dancer** - "How much does the robot's movements affect the performer's own movements?" **Machine Should Be Free** - "How much do you think a machine should have its own initiative and freedom during a collaborative performance?" **Dancer Should Lead** - "How much do you think the performer should lead the machine in the performance?" **Dancer Affect Robot** - "How much does the performer's actions affect the robot's movements?"

actions should influence the robot rather than the opposite. This result suggests that audiences perceived the robot to be autonomous; therefore, the robot's collaboration with the dancer forms a narrative in which the physical presence (robot) is assigned emotional characteristics while the remote presence (human dancer) is perceived as the interaction's leader.

Audiences interpreted the robot in human terms and with human emotions, contrary to the performer's interpretation of the robot as a device that can imitate human movements designed through a feedback process (5.2.1). The performer is aware of the various ways in which the robot can move, but the audience perceives the end result not as uncertain interactions but as harmonious, coherent action befitting the constructed narrative.

## 6 DISCUSSION

During COVID-19, we looked at how the virtualization of performance formats affected the performance community in China and Hong Kong from four different angles: the relationship between performers and technology (RQ1), performers' interpretations and expectations of how audiences will interact with them (RQ2), policy-focused effects on the performers and their communities (RQ1), and how performers adapted to a workflow with remote technology in a live distanced performance setting (RQ3). In this section, we discuss our findings regarding the mediating role of technology in online contexts, design implications for interactive distanced technologies, and study limitations.

### 6.1 Rethinking the Performer-Audience Relationship in Distanced Performance

Prior research shows that independent artists have generally accepted the use of remote platforms and have begun finding new engagement strategies while performing remotely [17]. In this study, we recapitulated earlier findings about limited attention spans in online formats and a lack of audience feedback [9, 39, 60]. The interviews showed the intricacies of performer-audience interactions as mediated by remote technologies like live streaming, Zoom, asynchronously shared video, etc. Participants related the way they perform in online media to being limited by the single camera angle and that the transmission medium limited the full power of their performances. In short, the

distant context requires a performer to treat the camera as a proxy for the audience. In other words, the performer must immediately interact with the camera to convince the audience that the artist is performing for them. In this format, we found that the performing body image is digitized, the 3D body movement is transformed into 2D, and the performers are physically isolated from their environment, removing sources of contextual feedback. However, while the online context reduces much of the sense of presence, it also provides opportunities for performers to adapt to technology and for technology to play a role in influencing the watching experience and outcome.

Our findings suggest that COVID-19-related pandemic-control policies have had a negative impact on the performers' professional well-being, performance formats, and psychology. The mask-wearing policy causes breathing difficulties and hinders the performer's facial presentation and audience interaction. The lockdown paradoxically liberates them from the time constraints of offline performances and provides more room for personal growth. We observed performers adapting to the online context and integrating interactive technologies into their art. They designed interventions based on their interpretation and audience expectations to address technical difficulties like time delays and lack of physical touch.

By examining artist participation and expression in remote performance paradigms, we observe the need to develop effective remote technologies for the artist community and gain a better understanding of how restrictions affect artist workflows and community connections. It appears that performers are affected not only by shifting roles but also by diminishing opportunities. In addition, they appear to adapt to remote technologies and alter audience perceptions to achieve a new type of performance, thereby extending our relationship with technology. This adaptation is most evident in the case study performance, in which the dancer learned to rehearse and perform with a robot she had never seen in person and imagined how audiences would perceive their collaboration.

In addition to adapting to the 12-hour time difference and the inability to see the robot, the performer had to imagine the differences between her body and that of the machine and use a feedback process to adapt to a collaborative remote performance process. Our work is a case study demonstrating how creative limitations can result in human adaptation to technological intervention.

### 6.2 Design Implications

The human-robot performance demonstrated that the performer must use counter intuitive techniques, such as visualizing her own limbs from the robot's perspective, in conjunction with constant feedback in order to effectively perform with the remotely controlled robot. In general, remote technologies restrict the performer's perspective, requiring her to use her imagination to comprehend what the audience perceives. Therefore, designers may consider developing an interactive, participatory system for online performance that enables live interactions between the audience and the performer, similar to live streaming in China[34], but not limited to text support.

In performance practice, virtual avatars and robots can provide various advantages to support the artists' workflow, such as helping with online collaboration, performing, and practicing to reduce inconveniences caused by physical distance [43]. Interactive formats can also be used in choreography to facilitate a direct connection between the performers and the audience, reduce the limitations caused by remote performance, and engage the audience in the dancers' movements [7]. Within this system, the choreography could develop based on the audience's behavior and the improvisation of the performers. Such a system would allow performers to sense the audience's presence and heighten the feeling of being observed. According to the findings of our interviews, the system should demonstrate to performers how audience interactions can be random and distracting (4.2).

As our findings (4.1.2) imply, remote technologies enable performers to adapt to camera-based screen communication systems, which limit their mobility and reduce their interactions with audiences in physical venues. Future-designed 2D systems may imitate the viewing experience in offline performances, in which the audience controls the viewing perspective by turning their heads and the camera that faces the stage. Changing the camera's pointing angle allows the audience to participate and interactively influence the performance's progression. As with 360 immersive systems, this involves centering the performer and allowing the audience to control the view. On the other hand, the performers may be able to physically sense the audience's gazes and respond to the audience's actions through their dance patterns or improvisations. Upon observing the performers' reactions, the audience may adopt a second layer of behavior. Consequently, a feedback dialogue similar to the one between performer and robot in our intervention could be created between these two groups, resulting in a performance that enables potentially rich and unexpected interactions.

Another way to affect the performer's interpretation of the remote performance is to change the robot's appearance to signal additional affordances that make particular interactions more likely[18]. For example, if we dress up the robot in pink and festive colors, it may give the performers an impetus to create particularly humorous or child-like movements. This suggests that for performance, the robot can be designed with its specific expressive identity in mind, much like how human clothing is designed [12], by providing a proper match to its task with performers. Moreover, humans are more likely to cooperate with robots of proper appearance for particular social tasks [20], suggesting that the robot's appearance should be matched to audience expectations during distanced performance-related tasks.

In general, future interactive interfaces for expressive performance need to consider adaptations of distanced performers already made to account for the lack of audience, physical touch, and spatial limitations in remote technologies.

### 6.3 Limitations and Future Work

While we recruited experienced participants with cross-cultural collaboration experiences, they may not represent the entire performance community. Most of our participants were from the same age range (25–35 years old) and related backgrounds (mostly Chinese ethnicity). There are different emphases on performance practices in Eastern and Western cultures. Eastern performances, especially Chinese ones, tend to be more formal and structured [62]. Some performance media in Chinese cultures, such as Peking opera, Kunqu opera, and Ethnic dance, have strict rules for costumes, makeup, gestures, and movements. Additionally, Chinese performances often emphasize harmony and balance, with performers aiming to create a visually pleasing and cohesive ensemble[36].

Western performers often have more freedom to interpret and personalize their roles and movements[22], which can result in a more varied and dynamic performance. In other words, performances tend to be more individualistic and improvisational [37]. Thus, Chinese performers may emphasize different processes compared to Western performers, such as coherence and harmony of execution, which may devalue the in-person performance paradigm. We hypothesize that Chinese performers may be more accepting of particular pandemic constraints, potentially leading to greater adaptation to the new performance platforms. To account for this, we would recruit more performers from different age ranges and cultural backgrounds to compare COVID-19's long-term impacts on the community based on their responses and experiences (e.g., the differences between younger and older performers).

Due to the fact that the interviews were conducted during COVID-19, we utilized Zoom and other online meeting platforms in lieu of in-person interviews, which could have affected the interviewees' responses due to a lack of comfort in discussing sensitive topics such as political policy and criticism.

Additionally, the effectiveness and engagement of remote performances can be evaluated from the perspective of the audience, but we only collected data pertinent to the performer's viewpoint. Zoom can also be used to treat the audience as separate entities in the human-robot performance. This may provide a unique perspective for comprehending the interaction, as each audience may have its own agency. As stated in Section 4.4.3, due to the pandemic, the online platform influenced the content of the performer's works, resulting in the acquisition of new skills and abilities. A greater need exists to investigate how these new skills interact with remote performances. Future research could compare online and offline robot performance to determine how acquiring skills for online performance influences robot interaction differently than in-person practice.

Future research could also explore the differences between performer and audience engagement in distanced and physical performances based on a workflow similar to the human-robot remote performance and consider the impacts of different practice areas in performing arts with cultural backgrounds. On the other hand, the differences between distanced performance conducted in different virtual platforms need to be clarified, including in the camera-based environment (Zoom and YouTube) vs. virtual environments (VR collaboration, 360, immersive tech), etc. The interaction on the camera-based platforms is flat since it is based on images on the screen and words on paper[5]. However, virtual and immersive methods provide users with a participatory platform to enhance their engagement and experience[13]. Thus, comparing the impacts and effectiveness of each platform is essential for further research.

## 7 CONCLUSION

Through 25 semi-structured interviews and one remote performance intervention, this work attempted to dissect the detailed process, mental framing, and social implications for performers as they adapt to the virtualization of the performance process during the lockdown and COVID-19. Performers used the limitations of the online remote format as creative constraints to augment their practice. They also treated Zoom and video conferencing software as metaphors for the movie camera gaze and lost the rich audience interaction found in real life.

This suggests that we should design for the support of expressivity in online formats not by using software designed for meetings to do expressive work but rather by designing for the ability to improvise, for remote device interactions, for differences in time and location, for the randomness needed in improvisational processes, and for the lack of audience engagement. Our work highlights the need for design at the personal workflow level, the creative technology level, and the social-community level for supporting performers in the era of distancing to overcome limitations in time and space for performative expression.

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