“Contradiction pushes me to improvise”: Performer Expressivity and Engagement in Distanced Movement Performance Paradigms

ANONYMOUS

The workflows of performing arts communities have been altered by the virtualization of typically in-person experiences, leading to shifts in performance venues and resulting in changes in expressivity and interaction. To investigate how virtualization processes affected the practice and conditions of performers and how they adapted to these changes, we interviewed 25 professional movement-based performers who have engaged in both live and online performances. We found that performers treated online performances akin to time-limited movie recordings without audience interaction. Instead of avoiding distanced venues, performers adapted to new limitations, inventing improvisation strategies in distraction-filled situations, using time and technical limitations as creative constraints. To examine how a distanced paradigm impacts dancers’ live-action workflow, we conducted a performance involving a dancer interacting with a robot at a distant location. The case study showed that the performer altered her rehearsal strategies to work with distanced technology and adapted to the live interaction with a distanced audience by imagining unseen interactions. This work provides insights to guide the design of interactive technology for virtual performances to account for the adapting strategies performers are currently taking to overcome limitations in time, location, and lack of presence.

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1 INTRODUCTION

Restrictions in gatherings have led to an increasing reliance of performing arts on online media [52], whileartistic expression has turned to technologies that provide more connected experiences for performers and audiences. Zoom, Twitch, Instagram, and web-based formats have been used as online venues for musicians and dancers [34, 40].

Collaborative performances in the theatrical setting have always relied on live presence, which is more difficult to achieve and measure in the virtual setting [33]. Recent work has explored the way presence is enacted in distributed performances using focused attention and visualized audience feedback [53], as well as multi-sensory and immersive technologies for enhanced subjective presence [33]. However, the recent Covid-19 lockdown created additional constraints and needs for performers to undertake such distributed interventions. This is particularly pressing during the prolonged pandemic response scenarios and its associated mental challenges in China, Hong Kong, and nearby Eastern Asian cultures [26], which have had a traditionally strong reliance on stage performance [45]. How are these performers’ workflows and perceptions altered in the context of virtualized paradigms?

This study investigates how the pandemic has influenced the movement-based performance community in China and Hong Kong in terms of expressivity and engagement in distanced performance paradigms. We conducted semi-structured interviews with professional performers about how the pandemic changed their performance practice. We

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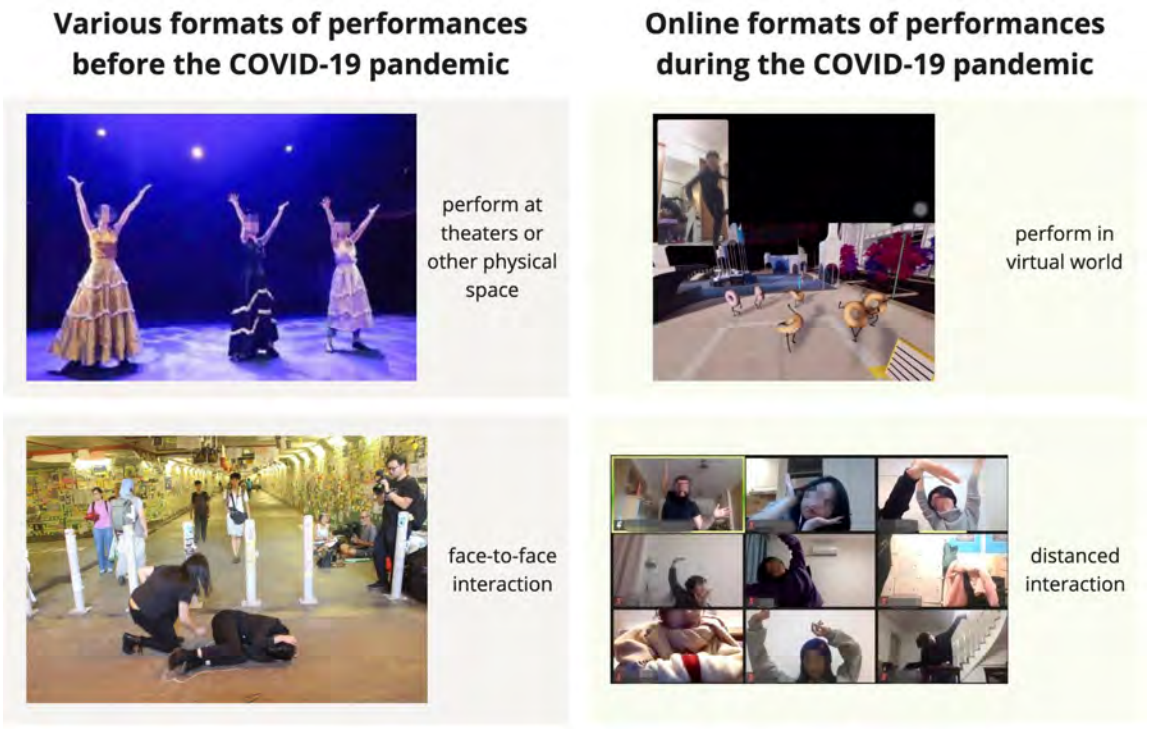

Fig. 1. Summary of shifts in artistic performances before and during the Covid-19 pandemic restrictions, with selected figures showing the particular performers interviewed in this study. **(Upper Left)** Performing live in a local theater with reduced audiences during Covid-19 (P16). **(Upper Right)** 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).

found that performing online was reshaped by technology, which determined how the performance was presented and how performers could interact with the audience. Performers saw these challenges as new creative constraints, but the lack of physical touch and sense of being watched led to less engaging experiences for both performers and audiences.

Our study focuses on designing and studying collaborative systems and technologies for the performance community. To understand the findings in a real, live remote performance where the performer's workflow and interpretation can be studied, we created a remote performance that allows the performer to interact with a robot in a remote performance venue. The Japanese performer worked with the robot remotely with only a limited perspective of view. This allows us to probe how a purely distanced performance format affects how a performer perceives interacting with a distanced robotic arm during the rehearsal and realization process.

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 impacts of the recent lockdown found that people in isolation endured negative shifts in their emotions, behavior, and cognitive function due to social isolation and loneliness[21]. These destructive effects are particularly pronounced for artists whose work relies on the human body [50]. What's more, performing arts communities have seen shifts in performance formats due to Covid-19 [25]. Social distancing has led to the cancellation and decline of physical art performance venues, and interaction modes of artistic performances have increasingly relied on online platforms [44, 51]. A range of diverse artistic media were explored in response to the limitations imposed since the pandemic [3]. Performing artists experienced disruptions to their daily lives and creative routines, forcing them to actively construct new strategies and technologies to cope with the new normal [8].

The transformation in performance since Covid-19 affects both the audience and the performer. Performance artists' interaction and visual experiences in their spaces are complex, entailing a physical interaction with the audience and the environment [37]. In the virtual format, the performer's workflow can be altered to fit the reduced engagement, leading to a new perception by the audience. Replacing the physical stage with a video chat interface leads to the blurring of identities between the performer and the audience [5], leading to new challenges for the performer to understand audience reactions in a less engaging format.

Despite these limitations, the performing arts can improve the collaborative interactions between people even through online means [35]. Online creative activities can increase interpersonal communication and connection and alleviate the negative effects of social distancing. In particular, social dance interventions can advance participants' body awareness and sense of self[43]. Moreover, distanced performance strategies allow the background of the show to be manipulated, so that creative interventions placing performances in particular contexts can leverage immersive technologies to situate the performance [49] more easily than building the stage background for physical performance.

2.2 Interactive Technologies and Strategies for Audience Engagement

Audience engagement is prioritized in performance production [13]. Combining emerging digital technologies and live performances serve to enhance the connections and interactions between performers and audiences. Mixed design strategies have been applied to engage audiences in interactive performances [10] so that audiences can better understand complex, layered conceptual works designed for them [22]. However, the application of performance technologies in dance performance burdens the choreography and production process since more rehearsal time is needed for integrating these interactive technologies into dance performance [27]. Recent studies have focused on applying interactive or reactive multimedia technology to dance performance and production. Motion capture has created digital interactions between audiences and performers[23]. This has led to creating of interactive dance works using live motion capture systems [1, 15, 23], which generates fine movement data for subsequent analyses [23]. Other research has explored 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, creating a sense of tension [56].

Movement improvisation is an area of dance research where interactive technologies has been applied [7, 38, 46]. Although improvisational artistry is involved in all live performances, technologies bring uncertainty and new challenges to the production of live performances since performers can change their movements according to the performing environment [7]. For instance, one interactive system called "Choreography" was employed to explore the impact of

avatar characteristics of motion capture on movement improvisation [38]. Since humans are often unaware of how technologies may be interpreted [28], dancers need to apply strategies to handle openness in improvisation [39]. As shown, improvisation is critical to human collaborative processes due to their dynamic and error-reflective nature[24], making it essential for computer-mediated movement communication.

2.3 Dance and Movement Research in HCI

Much HCI work has focused on how participants can engage in movement-based interactions using immersive and collaborative technologies. One work analyzed the tension between dancers and participants in an interactive movement installation [54], finding that dance performance is a mechanism that can encourage participants to actively engage with the interactive installation by using their body movements to control the display on the screen to create a collaborative dance performance. Mobile technologies have further been explored by a study using the Radical Choreographic Object (RCO) to investigate audiences' participation in dance performances using gesture-based interactions, finding that participants transfer their interaction modes from obeying it to re-interpreting and re-appropriating it [2]. Such engagements can also occur in VR, where dance communities can express themselves remotely [36]. Other aspects of the dance production process have also been explored, including a web-based collaborative tool for connecting choreographers for dance production[9], long technology-mediated long-term learning of dance-related processes such as the use of physical instruments[42], decomposition of movements sequences [41], and movement-based communication in remote partnering [32].

In regards to interaction with audiences, previous work conducted before the pandemic found that performers can often miss feedback from audiences in the distributed performance format due to the increased demands on the performer's attention, leading to implications for creating hybrid spaces that contain both physical and virtual interactions [53]. This is analogous to the case of group Zoom exercises classes, which shared the difficulties of lack of interactive feedback and demanding attention [19], which may be expected to occur in the distanced performance format. However, the latter's more collaborative nature may lead to different adaptations separate from learning processes. In the context of live streaming in China, audience and performer interaction was found to occur in a center-surround orientation, with audiences contributing interaction in the form of instant messaging[29]. This suggests audiences can become active agents of online performance experiences designed for performers and viewers.

3 METHODS

3.1 Data Acquisition and Analysis

To understand performer expressivity and engagement and explore the performer-audience connection in distanced performances, we conducted semi-structured interviews with 25 experienced performers by Zoom (14), Tencent Meet (3), and in-person (8). Among these performers 1, there were 4 working in classical performance such as ballet and opera, 4 contemporary dancers, 2 in Chinese traditional dance, 3 social dance performers (swing and Latin), and 3 performers working in a acting role in the theatre. 4 performers engaged in the artistic practice of behavioral performance in the tradition of Marina Abramović, 3 were primarily teachers of dance, while 2 were involved primarily in online performances.

We recruited experienced performers in Hong Kong and China with diverse backgrounds in different movement-based arts. We chose only interviewees with experience performing in at least one online (or otherwise socially distant through technology) performance during the Covid-19 pandemic alongside a previously extensive practice that includes

at least two live performances in their careers (frequently up to 10 or more). Institutional research protocols were approved and followed strictly during the interview process. We found performers by direct messaging and posts on social media platforms (WeChat, WhatsApp, Instagram). Each interview lasted between 30-45 minutes. Interviews were conducted in English or Chinese and recorded in audio. The Chinese interviews were transcribed into English after removing personal and identifiable information. 25 participants (3 male, 22 female) were interviewed (Table 1). 7 performers were interviewed in person as they were physically available[48].

3.2 Interview Procedure

During each semi-structured interview, interviewees were asked to introduce their artistic practice and performance experiences briefly. Then, the interviews 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 times, the difference between conducting performance online or in a physical place, and how they expressed themselves in online performance.

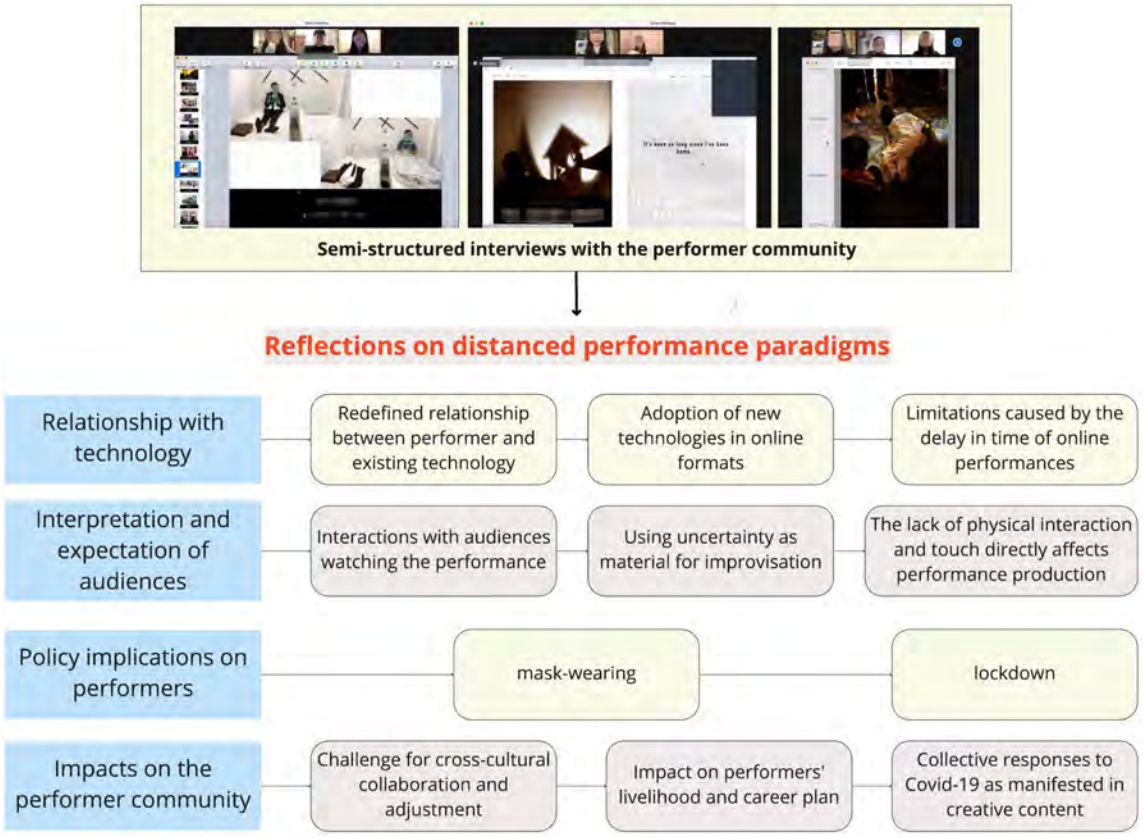

Fig. 2. Research methodology and key findings. **(Top)** Screen captures from semi-structured interviews conducted in Zoom, **(Bottom)** Diagramming the key findings.

3.3 Data Collection and Analysis

We used open coding to thematically analyze the interview transcriptions. One researcher took notes during the interviews and transcribed data into text form. We then obtained the possible codes based on the transcription of the interview discussion. Two researchers independently classified the interviews into the previously obtained codes, which were then categorized into different themes [47]. After categorizing, all three researchers analyzed the themes together for presentation.

4 RESULTS

Our interviews revealed four aspects in which performers were affected by distanced performance: adaptation with technologies designed for distanced communication, alteration in performers' interpretation of audiences, adaption to policy measures on distancing, and changes in the community of practice in content and collaboration.

4.1 Performer's Relationship with Technology

4.1.1 Redefined relationship between performer and existing technology. With the professional performers interviewed, online performances occur most often on platforms like Youtube and Zoom, where the action occurs in front of a

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

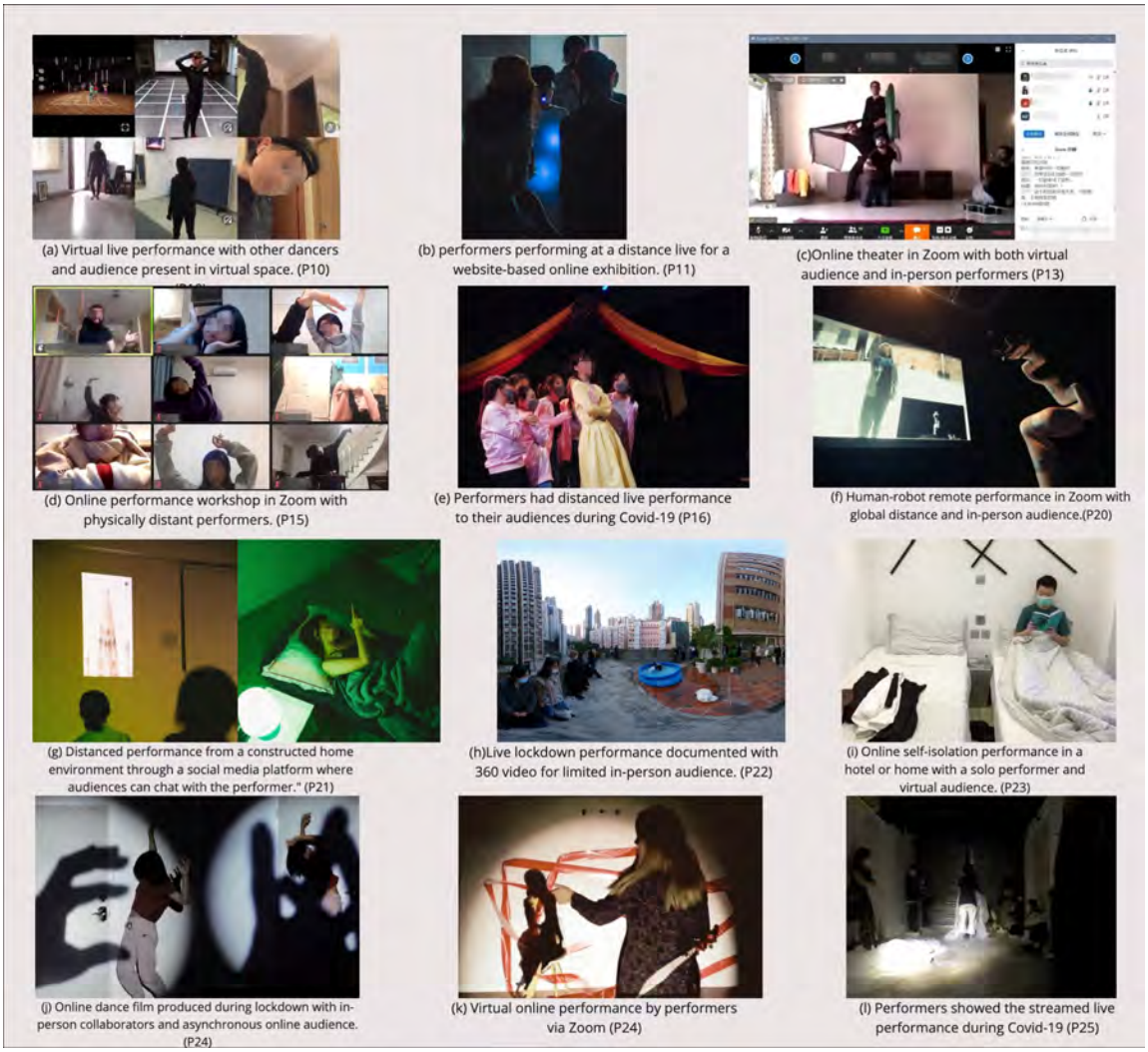

Fig. 3. Dance practices of professional performers engaged during the interview. Photos are used with permission from the interviewees. (a) Live performance in a virtual environment using motion capture. Other dancers and audiences are in the virtual venue also. **(P10)** (b) Performing at a distance live 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 the 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, and audiences watch in person (40 people) and online. **(P16)** (f) A human-robot remote-distanced performance in Zoom. The performer and robot are located 12 hours apart; limited audiences view in person. **(P20)** (g) A distanced performance in which audience members can 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. No other performers share the stage. **(P21)** (h) Live behavioral performance documented using 360 videos during the lockdown. Limited audiences are in person, with 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 is 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 on a website. Thus both performers and audiences are in separate physical spaces. **(P24)** (l) A streamed distanced live performance. Other performers were in-person, while audiences watched live online. **(P25)**

webcam. Interviewees pointed to the similarities between conducting streamed performances in virtual platforms and being recorded in movie shoots (e.g. P4, P10, P18, P19, P22, P25) noting that they both occur asynchronously. "Online performance is like making a movie, we only have to satisfy the director, because no other audience members are in our own spaces... thus we have to control things in greater detail and there's less energy than in live performances" (P4). The interviewees agreed that in the absence of an audience in their performance space, the Zoom window becomes a camera to satisfy, just as in movie sets where the film camera has limited perspective. Thus they were less willing to play to the audience as in live theatre, and instead perform to a "multiple takes" model used in filmmaking (P10).

Inspired by these constraints, performers were led to take up unfamiliar technologies like video recording (P22) and web broadcasts (P18, P19). “Due to the epidemic, I had some inspirations and started to apply filmmaking 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 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 our participants to rethink their relationship with audiences and how technology enables the relationship: "We’re closer to rethinking what technology is in our life 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 media that connects the performers and the audiences, "it dominates the performance" as well: "The camera determines the perspective of the audience, 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 to 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, 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 to 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 media 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 choose 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 liveness: “Going to a venue has an association of quality experience due to expectation and commitment by the audience; this cannot be shown even immersively” (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 of P11.

As opposed to simply adapting to the online format, certain performers have also explored innovations in performance technology as part of their new renewed focus or practice (P1, P7, P10, P21, 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). 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 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 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 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). Participants were often frustrated by the delay in online performance when performing online to instruct the students (P1, P4, P10, 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 in the form of the idea of "deferral" can mean pushing things that can occur now to later points within a single performance, or mean pushing a scheduled show to later points in one's own career. Deferral thus appears to be a metaphor that can capture performer's emotional state. On the other hand, it pushes the artist to think about how this kind of frustration can be "transformed into another layer of meaning" (P1), relating the temporal deferral in the micro-scale of the delay in online performance to one's performance practice, where subscriptions and scheduled shows have been canceled: "The online performance has a delay that is like a metaphor for how our lives have been altered." She notes that the online situation has "changed the way we spend time together" but finds it to be "an opportunity to adapt" (P1).

The notion of time seems especially relevant in the online regime. For one performer, the amount of time available seems especially pressing in formats that require recording and streaming, as in 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 of 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 it, 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 constructed a dialogue loop between the performer and the audience. "When I was doing the live performance, the fact that I'm being watched motivates me and energizes 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 audiences' 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).

Online performance redefines how performers can interact with audiences. Previously in live performances, performers were being watched in person by audiences, and they "could immediately get audiences' feedback" (P2) and could have "emotional communication and feedback" (P3). "This real-time feedback triggers energy in me" (P2). This process constructed a dialogue loop between the performers and the audience. "When I was doing the live performance, the

fact that I'm being watched motivates me and energizes 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 audiences' cheer [in live performance] that really opened up for me to respond through dance patterns." (P8) Another noted that it's really the "interaction with space that the audience occupies" that provides the material for one's creative choices (P14), which appears to differ from the "single abstract viewer when trying to perform online."

In other cases, however, even the need for audience interaction is an adaptation to be overcome by performance practice in the pandemic era. 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 that 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 have 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 collective interactions found onstage.

4.2.2 Using uncertainty as material for improvisation. The ability to improvise during performances creates a sense of agency for both the performer and the audience [7]. 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 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 the 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 the 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, even the inability to touch and feel the temperature of someone has been used by performers 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 compulsory 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 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 and 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 career livelihoods around (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 performance 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 class" (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 impacts of the lockdown mediated by emerging 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 [myself] 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, 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 [14], leading to creative solutions using technology to help mitigate these challenges [8]. Several interviewees noted difficulties conducting international collaboration via virtual platforms due to time and location differences: "Due to travel ban, mandatory quarantine, and such policies 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 overseas study noted that Covid-19 also brings new inspirations in 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 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 our community 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 direction and only a few people can persist in it" (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 effects of online shifts in performance venues on creativity [50] were reflected in our interviews, but the participants also noted that they would add personal reflections into their artistic creation and performance theme 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 its 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). 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 probed performer workflows and expectations, they did not inform us what performers do during a typical online performance. The interviews also could not follow a performer's real life preparation process dealing with concrete problems using moment-to-moment adaptations to the task during the rehearsal and performance processes. To understand how the performer's expressive abilities and collaboration with a distanced performance system may be affected in a live distanced performance situation that included a live distanced audience, we created a Zoom-based performance (Fig. 4) that presented a dance artist and a robotic arm separated by two opposite locations in the world and 12 hours of time difference. We used this opportunity to investigate how the performer rehearses and interacts with a remote, independently acting robot in order to make an impact on audiences at a distance. We then studied how the performer interprets working with the remote-performance technology as well as how audience perceive this technology in the performance outcome (RQ3).

The interviews with performers could not address the particular habits and perceptions about specific actions in rehearsal and performance. Thus, we wanted to create a physical remote performance to examine some of the issues alluded to in the interview studies that could not be fully understood without a virtual performance occurring. As such, we engaged a dancer from the interviews (P20) to perform on Zoom at 9 am local dancer's time, with a robotic arm collaborating with her at 9 pm local performance venue time. The dancer's image is projected in the 9 pm venue for a live audience (25 people) along with the physical presence of the robot. This case study performance focuses on how the dance artist undertakes the rehearsal and performance processes, working with a remote robot that she can only see through limited perspectives in order to narrate a story through movements to engage a remote audience.

5.1 Design and Implementation

5.1.1 Design rationale based on interview study. The remote performance was designed based on the interviews with performers about ways to facilitate their expressivity and collaboration. The previous considerations on lack of improvisation within online venues (P1, P2, P4, P6, P7, etc.) led to our introduction of live audience engagement at the location of the robot arm. Because performers shunned the individual Zoom-like audience, we decided to create one large live audience group following social distancing guidelines that observed in one camera angle in Zoom by the performer. Due to the performer's lack of a perceptual model for what the audience is going through (P6), we decided to minimize the amount of information the performer needs to multitask with (P1), creating one audience instead of separate ones gazing randomly and distractingly at the performer.

In consideration of the lack of touch and presence in remote performances (P1, P3, P5, P9), we decided to employ a robot arm in our performance that interacts with the dancer from afar. This would give the dancer a remote presence to choreograph with for the story of the performance. Taking inspiration from P2's taking of the audience's hand and P10's exploration of virtual interactions, we created a system that attempts to capture how the performer can engage the audience by performing in collaboration with a robotic system. We chose to use an industrial-level robotic arm because it created the appropriate scale for the in-person interaction while providing ambiguity to the robot's identity, which can be interpreted either as an arm or as a head. The robot arm was not meant to imitate human movements completely because we wanted to emphasize that the robot is indeed not human. Rather, it provides a presence in the space that of the audience that interacts remotely with the performer.

Although the performer still cannot physically interact with the audience, the robot arm does have a presence in the live audience's space. It in turn creates a story with the performer, leading audiences to perceive both online and offline elements in the performance. We acknowledge that such a robot does not fix the touch sensation problem. Instead, we engaged with the performer to understand how she may work with the remote presence system in forming a mental model of how the touch-like interactions would occur throughout the rehearsal and performance process. For the dancer, we designed the intervention to reduce the performer's impression of dancing in front of a movie camera, as found in discussions (P1, P21, P 22), in favor of collaborative interaction that forces the performer to see what her

Fig. 4. A distanced human-robot performance took place at 9 am at the dancer's location and 9 pm 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 am and the theater at the same time at 9pm 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.

partner robot is doing in real-time from a limited perspective, thus avoiding the "performing for recording" paradigm encountered by (P10, P11, P22).

Other variables reflect the limitations faced by the remote performers that we did not attempt to design for but rather wanted to reflect in the performance to study further how the performer can adapt to them. The limitations due to delay in time due to time differences (P1, P4, P21) were reflected in our simultaneous performance in the two remote locations despite timing difficulties on both sides in both rehearsal and performance days. Despite difficulties during the rehearsal, the mask-wearing limitation (P10, P12, P15, P25) was followed at the performance and the audience locations. The mask-wearing was relaxed for the dancer during the performance due to the lack of oxygen supply (P10) during draining continuous dance sequences. Finally, the intervention engages our performer's community, relieving her from the Covid-19 shutdown that occupied her practice, as referred to by those who created new adaptations involving their communities (P13, P15, P16, P22, P25).

5.1.2 Implementation and configuration. For implementing the performance, we used a Zoom meeting to link the dancer and the performance venue on the main computer. The meeting shows the dancer with the name, and toolbars turned off. The main screen is pinned on the dancer, with a small drag-and-drop window to show the robot from a direct-on perspective (Fig. 4 Left). A video camera directed at the robot is connected to the PC, sending the live view to the dancer on Zoom. The dancer can hear the audio setup from the program and microphone in Zoom and thus hear the music for the live audience during the performance and rehearsal. One laptop is connected to the robotic arm for running a program that allows interactive control of different movements from the management team. A different laptop and the main PC are connected to the projection system and Zoom, respectively. The lighting in the performance venue is controlled by the spotlights on the floor, main lights, front lights sequence, and the backlight sequence.

We employed the XArm 6 industrial arm with a gripper (UFactory, Shenzhen) for our study. The robot dance and gesture movements were programmed by modeling and recording the movement using UFactory Studio, then tuning the joint positions in Python code. Custom Python code is written to create a user interface for controlling each of the movements of the robot (Fig. 6) as choreographed by the dancer and director. During the performance, the staff is assigned to select from the preset of possible gestures for the robot arm using the user interface.

5.1.3 Narrative structure and choreography. Fig. 5 shows the story of the performance. In the beginning, the robot and the dancer meet each other. The dancer will make a greeting gesture with the robot and act like meeting a real person; then the robot will greet the dancer with a reaction. Next, the dancer tries to teach the robot simple dancing steps or gestures. In response to each gesture, the robot tries to imitate the step but cannot faithfully reproduce the movement. The dancer becomes disappointed and leaves the stage, while the robot asks the audience for help by standing up. With the audience's encouragement, the robot begins to practice movements, improving movement smoothness with time.

In the next section, the dancer returns to the stage on Zoom and dances alone while the robot watches and learns. Soon the dancer and robot become in sync, dancing with a pre-arranged choreography to original music. Next, the robot dances alone, incorporating what he learned from the dancer with non-human steps that the human torso cannot imitate. Finally, the dancer wants to lead the robot's movements again, but the robot begins to have rebellious ideas. The dancer tries to make three simple dancing steps the same as the ones she teaches at the beginning, but the robot does not follow them and instead comes up with original moves. The dancer becomes more obsessive about controlling the robot and turns off the Zoom that connects them because she can no longer manipulate it. Disconnecting Zoom also causes the robot to shut down, ending the performance.

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.

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.

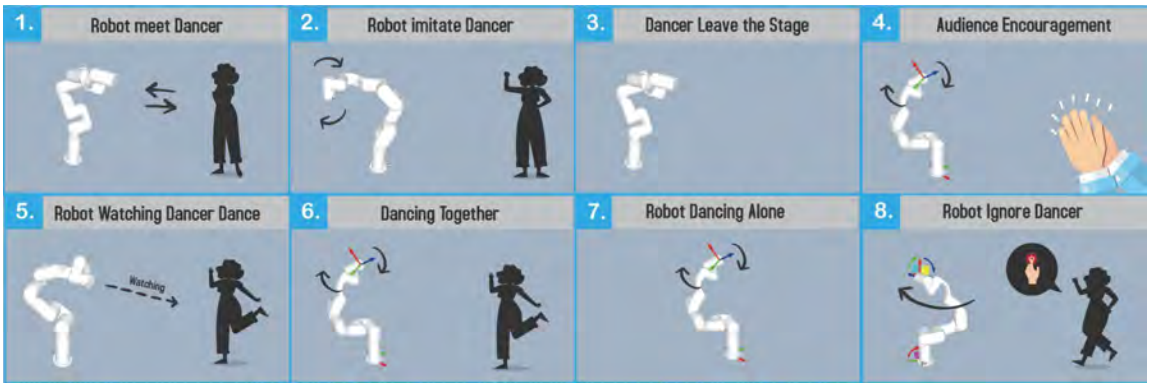

Fig. 6. Storyboard for the remote performance. The robot and the dancer greet each other. The dancer tries to teach the robot how to dance, and the robot tries to imitate it. The dancer feels disappointed that the robot cannot imitate the steps and leaves the stage. The robot asks the audience for encouragement 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.

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 in 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: "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. Here 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 limitation 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, it rotates 360 degrees, so I had to imagine how to alternate the robot's joint to my joint because the robot does the movements that I never imagined before, never tried before." Thus, throughout the rehearsal, the performer had to adapt to a new interaction where she danced with a partner who did not move like her. By imitating a non-human form that did not move like her that she could only observe from a single viewpoint, the performer created an interaction which she cannot observe from the point-of-view of the audience, leading to uncertainty in how that interaction is perceived by the audience.

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 to 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 constraint 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 in choreographing the motions with the robot, we asked the audiences directly for their feedback regarding their interpretation of the performer's creative intervention (n=20) to probe whether the performer's expectations and perceptions of the audience experience were congruent with the outcome. In particular, we surveyed how audiences interpreted the interaction between the dancer and its independently controlled robot partner. We distributed the questionnaire to 20 audience members (n=20, 12 male, 6 female, 2 non-binary) after they experienced the entire performance. RStudio was used to process, analyze, and plot the data. The audiences' short answers to questions about their understanding of the interaction between the performer and the robot were then coded 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, A21). Audience members appeared to understand and interpret the movements of the robot based on human emotional interpretations (A4, A10, A11, A13, A16, A18, 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.

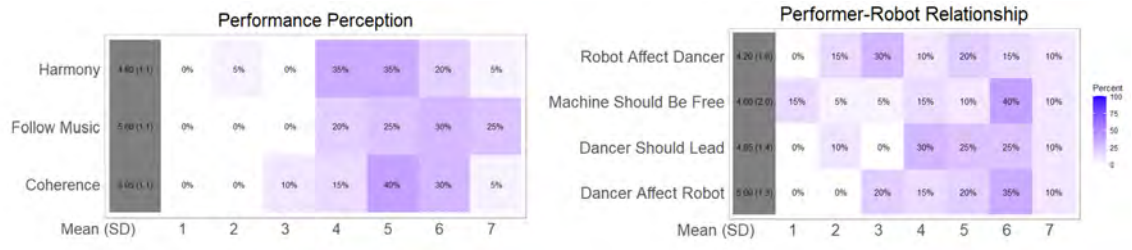

Fig. 7. Audience perception of performance and performer-robot relationship (n=20). Ratings are not significantly different (Coherence vs. Harmony p=0.4206, Coherence vs. Follow Music p=0.1448, Robot Affect Dancer vs. Dancer Affect Robot p=0.1030, Dancer Should Lead vs. Machine Should be Free p=0.9889, 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?"

5.2.3 Audience evaluation survey findings. Quantitative analysis of the audience survey (n=20) shows that the performance itself was perceived to have a high degree of harmony and coherence between dancer and robot movements. The robot's musicality (how well it follows the music) is stronger still, perhaps due to the choreographed nature of the sound.

In terms of the performer-robot interaction, audiences particularly felt that the robot should have its freedom during a performance, reflecting the perception of personality and emotion in the robot. They also felt strongly that the dancer's actions should affect the robot rather than the other way around. This result suggests that audiences interpreted the robot as independent, so its collaboration with the dancer forms a narrative in which the physical presence (robot) is given emotional characteristics while the remote presence (human dancer) is perceived as the leader of the interaction.

Together, the audience evaluations showed that audiences interpreted the robot in human terms with human emotions, in contrast to how the performer interpreted the robot as a device that can imitate human motions designed via a feedback process (5.2.1). The different ways the robot can move are apparent to the performer, but the audience sees the end result not as uncertain interactions, but as harmonious, coherent action befitting the narrative constructed.

6 DISCUSSION

We investigated how the performance community in China and Hong Kong was affected by the virtualization of performance formats during Covid-19 from four perspectives: the relationship between performers and technology (RQ1), performers' interpretation and expectation regarding audience interactions (RQ2), policy-focused impacts on the performers and their communities (RQ1), and how performers adapted to a workflow with remote technology in a live distanced performance scenario (RQ3). In this section, our findings are discussed concerning the mediating role of technology in online contexts, design implications for interactive distanced technologies, and limitations of the study.

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 [16]. In this study, we recapitulated earlier findings about limited attention spans in online formats and a lack of audience feedback [8, 33, 53]. 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 to online media as 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 performers' professional well-being, performance formats, and psychology have been negatively affected by the pandemic-control policies amidst Covid-19. The mask-wearing policy creates difficulty breathing and impairs the performer's facial presentation and interaction with the audience. The lockdown paradoxically frees them from the time constraints of offline performances and gives them more room for personal development. We saw that performers have adapted to the online context and applied interactive technologies to their artistic creation, such as trying to design interventions based on their interpretation and expectation of audiences to overcome challenges caused by technical issues like the delay of time and lack of physical touch.

By examining artist engagement and expression in remote performance paradigms, we observe the need to create effective remote technologies for the artist community and better understand the impact of restrictions on artist workflows and community connections. Performers appear to be affected not only by changing roles and decreasing

opportunities. They also appear to adapt to remote technologies and change audience perceptions to achieve a new type of performance, expanding our relationship with technology. The case study performance shows this adaption most vividly, as the dancer learned to rehearse and perform with a robot she had never seen in person and imagined how audiences would view their collaboration. The performer not only adapted to the 12-hour difference and the limitation in seeing the robot, but she also had to imagine the differences in the bodies between the machine and herself and used a feedback process to adapt to a collaborative remote performance process. Our work is a case study of how creative constraints can lead to human adaptation to technological intervention.

6.2 Design Implications

The human-robot performance showed that the performer has to use counter-intuitive methods like visualizing her own limbs from the robot's view, combined with constant feedback, to effectively engage in performing with the remotely operated robot. In general, the performer is limited by the viewpoint that remote technologies offer to the performer, who must use her imagination to understand what audiences perceive. Therefore, designers may consider an interactive, participatory system designed for online performance capable of live interactions between the audience and the performer, much like live streaming in China[29], 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 a physical distance [37]. Interactive formats can also be used in choreography to facilitate a direct connection between the performers and the audiences, reduce the limitations caused by remote performance, and engage the audience in the dancers' movements [6]. Within this system, the choreography could unfold according to the audience's behaviors and the performers' improvisation. Such a system would enable the performers to feel the audience's presence and help enhance the sense of being watched. Per our interview findings, the system should show performers how audience interactions can be random and distracting (4.2).

As suggested by our findings (4.1.2), remote technologies enable performers to adapt to camera-based screen communication systems, which decrease their interactions with the audience in physical venues and limit their movements. Future-designed 2D systems may mimic the watching experience in offline performance – where the audiences control the perspective of watching with their head-turning – by controlling the camera that looks onto the stage. Thus the audience can participate and interactively influence the performance's progress by changing the camera's pointing angle. Note that this involves centering the performer and allowing audiences to control the view as in 360 immersive systems. On the other side, the performers can potentially physically sense the existence of the audience's gazes and react to the audience's behaviors with their dance patterns or improvisations. The audience could have another layer of behaviors when they see the performers' reactions. Thus, a feedback dialogue akin to the one between performer and robot in our intervention could be created between these two groups, leading to a performance that allows for potentially rich and unexpected interactions.

Another way to affect performer interpretation of the remote performance is to change the robot's appearance to signal additional affordances that make particular interactions more likely[17]. 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 [11], 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 [18], 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 ranges (25 - 35 years old) and related backgrounds (mostly Chinese ethnicity). There are different emphases between performance practices in Eastern and Western cultures. Eastern performances, especially Chinese ones, tend to be more formal and structured [55]. 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[30]. Western performers often have more freedom to interpret and personalize their roles and movements[20], which can result in a more varied and dynamic performance. In other words, performances tend to be more individualistic and improvisational [31]. 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 adaption 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 long-term impacts on the community based on their responses and experiences (e.g., the differences between younger and older performers).

Since the interviews were conducted during Covid-19, we used Zoom and other online meeting platforms instead of in-person interviews, which could affect interviewees' answers due to a lack of comfort level with opening up about topics like political policy and criticism. Additionally, the effectiveness and engagement of distanced performances can be evaluated from the audience's perspective, but we only collected results pertinent to the performer's perspective. In the human-robot performance, we can also apply the audience as separate entities in Zoom. This may provide a different perspective to understand the interaction since each audience may have its agency. As mentioned in 4.4.3, due to the pandemic, the content of the performer's works was influenced by the online platform, leading to the acquisition of new skills and abilities. There is a greater need to examine how these new skills interact with remote performances. One future study could compare online and offline robot performance to see how acquiring skills for online performance leads to different engagement with the robot than in-person practice.

Future research could 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 and immersive tech), etc. The interaction in the camera-based platforms is flat since it is based on images on the screen and words on paper[4]. However, virtual and immersive methods provide users a participatory platform to enhance their engagement and experience[12]. 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 limitations of the online remote format as creative constraints to augment their practice. They also treated Zoom and video conferencing software as a metaphor 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 designed 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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