Routledge
Taylor & Francis Group

International Journal of Performance Arts and Digital Media

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rpdm20

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To cite this article: Atau Tanaka (04 Apr 2024): Telematic music transmission, resistance and touch, International Journal of Performance Arts and Digital Media, DOI: 10.1080/14794713.2024.2329836

To link to this article: https://doi.org/10.1080/14794713.2024.2329836

INTERNATIONAL JOURNAL OF PERFORMANCE ARTS AND DIGITAL MEDIA
https://doi.org/10.1080/14794713.2024.2329836

Telematic music transmission, resistance and touch

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ABSTRACT

This article retraces the history of telematic performance from early videophone experiments by the Electronic Café in the 1980s, through a series of ambitious digital art installations at museums like the Centre Pompidou. Onto this history, I map a series of netmusic projects I initiated in this period, from ISDN performances at the Sonar Festival to my installation Global String at Ars Electronica. This sets the context for collaborative online performances held during the COVID pandemic with artists like Paul Sermon and the Chicks on Speed. I finish by describing the Hybrid Live project connecting Goldsmiths and Iklectik Art Labs in London with Stanford University's CCRMA and SFJazz in California. I describe the low latency audio transport used, the importance of audiovisual synchronisation and the computer vision abstractions resulting in a London-New York remote dance performance. By situating current work in these histories, and closely examining the qualities of the network necessary for the transmission of a sense of embodied experience – and therefore trust – we understand that network performance occurs in its own space, one distinct from physical co-presence.

ARTICLE HISTORY
Received 17 September 2023
Accepted 20 February 2024

KEYWORDS
Network music performance; streaming; netmusic

Introduction

Networked performance was born with a cry for help in 1876 – Alexander Graham Bell exclaimed 'Mr Watson, come here!', without knowing that his invention, the telephone, had started to work (Fineberg n.d.) (Kahn 2013). Whilst remote communication by the transmission of codes existed already with the earlier invention of the telegraph, the telephone put sound on the wires, and with the sound, a sense of liveness – of 'being there'. It is indeed based on this that for decades, into the 1970s, the American telecom operator, Bell Telephone then AT&T, advertised the attraction of making a long-distance phone call as, 'The next best thing to being there.' (Bell System Advertisements n.d.)

The COVID pandemic brought a flurry of online conferences, symposia, happenings and performances. It seemed somehow as if network music performance was being invented. I was invited to participate in *Pandemic Encounters* by Paul Sermon and Randall Packer (Sermon, Packer, and Kuhn 2020). The feminist performance troupe, Chicks on Speed invited me to be remote Zoom performers in their *Corona Improv*

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Sessions at Festival Ars Electronica in Linz (Corona Improv Sessions n.d.). But as we will see, between Bell's cry for help and Corona Improv, there is a rich history of network music performance (NMP). This article retraces a partial history from the 1960s to the present time of key telecommunications works. This era in art practice importantly followed a societal transition from analogue to digital technology. Parallel to a survey of the field, I describe a personal history of 25 years of experiments and projects that respond, in sound and music, to the conceptual and media propositions made by artists in the field.

Liveness

In his investigation of the dynamics of live music in concerts, Philips Auslander uses the term, 'liveness' to describe the expectancy that is established by a live performance (Auslander 2008). What is at stake, according to Auslander is a form of *authenticity*. He opens the book by describing the then famous Milli Vanilli scandal, where the pop duo was discovered to have lip synched in concert to their album recording. Whilst recordings were representations of live performance – documentation, archive, the next best thing to having been there. The fan, if unable to go to the concert, could buy the record. This all changed with the multitrack innovations of Les Paul and Mary Ford where multitrack overdubbing was invented (Cormier 2016), and the painterly use of the technique in the highly filigree studio production of George Martin and the Beatles in the album, *Sgt Pepper's Lonely Hearts Club Band* (Hannan 2008). No longer was the recording the poor substitute of the live, its painterly production possibilities created new forms that then artists had difficulty recreating on stage. Where once recording represented the live, in the era of post-production the live sought in vain to represent the studio. In trying to do so, the artist, denounced by the public, lost face, failing the authenticity test.

While the Milli Vanilli scandal has faded from public consciousness, the public interest in authenticity remains. A recent article in the New York Times describes a radio programme, *Tinydesk,* where the producer invites well-known artists, not into the studio, but to his office at National Public Radio (the American public radio in Washington DC), to perform at his desk, in a sense, 'unplugged'. According to the article, this is seen by listeners as the ultimate test of authenticity (Jackson 2023). As studio effects like autotune can today correct an out of tune singer, authenticity at the desk of the radio host has become the ultimate challenge of musicianship – to prove the ability to sing in tune live, and to deliver on liveness.

For a media theorist like Auslander, the mediation by means of recording or broadcast technology impinged on a sense of authenticity and thereby liveness. Two decades following its initial publication, in today's networked culture and narcissism of social media where we edit the presentation of our daily lives, correcting all matter of mistakes with filters and AI photography, what has become of the notion of authenticity? Does the technological mediation of network music affect the authenticity of a streaming performance? Can we recover a sense of liveness, risk and spontaneity when performing over networks? Based on my experience taking part in the Corona Improv Sessions, the Chicks on Speed do indeed conjure a wild theatrical, costumed, affected performance all while being completely, authentically in the improvisatory moment, integrating the contributions of remote teleperformers. In the sections that follow, we will retrace the history of network music performance, situate it within wider contexts of new media art of the time, and reflect on concepts of feedback, resistance and intimacy (Figure 1).

Figure 1. Chicks on speed: *Corona Improv Sessions*, Festival Ars Electronica 2020 (photo: Petra Karner).

Early works

Twenty years after Bell's cry for help and subsequent patent for the telephone, the first electrical music instrument, the Telharmomium was born. In 1896, Thaddeus Cahill created a system of tonewheels to generate sound (Weidenaar 1995). The control console was so massive, that it was kept outside the concert space. Performer input was captured by the console and transmitted over wires to the auditorium and heard on horns. The remote performance control paradigm adds to Bell's direct audio communication to establish the dynamics composers and musicians would explore with network music.

The composition of telematic music can be retraced to John Cage. His Imaginary Landscape No. 1 was originally intended to be performed in two adjacent rooms at the radio, to be mixed together in a control room (Key 2001). Max Neuhaus was an American composer and percussionist who pioneered soundwalks with his Listen series. 'Networks' were for him one of the 'vectors', or types of musical works (alongside Place, Moment, Performance, Walks, Passage, Sensation, Invention). Networks, for him, were music for people, public activities that recall Chrisopher Small's idea of *Musicking*. Neuhaus' *Radio Net* project can be thought of as a prototype for telematic music (Kim-Boyle 2009). He would take over a radio station for a period of time, and open up multiple telephone lines, inviting listeners to call in. The radio broadcast became the sum of all sounds from the dial-in participants. His ultimate vision was to take over a radio station for 24 hours or more, something very difficult with hierarchical control of access to broadcast resources. Just at that moment, fortuitously for Neuhaus, the public roll out of the Internet meant that he could replicate

the Radio Net concert on the web. He created, with Phil Burke and Jason Freeman the Auracle.org site (Freeman et al. 2005), which remains online to this day.

Media art

The potential of telecommunications in happenings and exhibition work began to be explored in the 1980s in the field of new media art. This history can be retraced to Kit Galloway and Sherrie Rabinowitz, who, as the Electronic Café, created a venue and a series of events to create a cultural mise-en-scène of telepresence over early videophones (Galloway and Rabinowitz 1989). AT&T at this time had created future product prototypes to transmit slow-scan black and white imagery over standard analogue telephone lines (POTS, or 'plain old telephone service') ('History of Videotelephony,' 2023), the idea being that 'The next best thing to being there' could be even better seeing your correspondent. The slow scan videophone was a plug-and- play telephone set that could be used on a traditional telephone line, thereby proposing this step change in communications interaction without upgrading copper infrastructure. By hacking these devices, the Electronic Café used them, not for personal communications, but for long-distance happenings where communities of fascinated people could 'reach out'. In a time decades before fax, the mass take up of email and Zoom, this was the harbinger of artistic forms of tele trust building.

The most famous tele-happening in the Electronic Café's oeuvre was the *Hole in Space* (1980), connecting participants in New York with the crowd at the Electronic Café in Santa Monica (Galloway and Rabinowitz n.d.). The imagery was grainy, black and white stop-frame photography, taking up to two seconds or more to transmit one frame. While the video was too slow to represent motion, the audio was transmitted in real time over the telephone line. So the two sides could call out to one another while watching each other in a slow stroboscopic freeze frame pantomime. Despite the slowness, the picture added a sense of authenticity, while the audio carried the liveness of communication. In this stuttering way, a form of teletrust was established – enough that the simple act of connection and calling out across the continent fulfilled artistic intent (Figure 2).

Figure 2. Electronic Café's *Hole in Space*, 1980 (photo: Kit Galloway, Sherrie Rabinowitz).

I visited the Electronic Café in 1993 when they hosted an 'off' event connected to the Association of Computing Machinery's annual SIGGRAPH conference. In the main conference, the movie Jurassic Park showcased the latest innovation in computer graphics adopted by Hollywood. With the radical French group, Les Virtualistes we took a break from SIGGRAPH to visit Galloway and Rabinowitz. It was there, that we learned that digital telephony was in preparation and that new videoconferencing technologies would soon be available on the Integrated Services Digital Network (ISDN) ('Integrated Services Digital Network,' 2023). There began a series of collaborations I would carry out with Les Virtualistes, and musicians in Japan, Australia, Spain, France and America of telematic concerts. In the period 1995–1998, we performed a series of ISDN concerts, connecting one of the first editions of the Sónar Festival in Barcelona with Les Virtualistes in Paris, the HERE arts center in downtown New York with Paris, the Musique Action festival in eastern France with artists in Melbourne Australia, and finally the Cyberia Internet café in Tokyo with the Web Bar in Paris.

Despite its promise, ISDN was never fully rolled out outside of business and military networks, except in Japan where ISDN was deployed in public telephone booths, allowing on one occasion an artist to perform from a phone box connecting with musicians in Paris. Otherwise, artists wanting to use ISDN needed infrastructural support. The brief flourishing of cybercafés in the late 90s made them apt venues for telematic concerts. At the Sónar Festival in Barcelona in 1995 (Caballero 2003), we had sponsorship from Spanish national telecom operator Telefónica, and from the videoconferencing equipment manufacturer Polycom. Soundcheck for the concert was typically taken up not in checking the levels of the different musicians and their instruments, but by waiting for the telephone engineer and the videoconferencing product manager to hook everything up. The artist's intent here was to go beyond the 'hello can you hear me?' of the *Hole in Space* to actually play music across distance, using disrupted visual flow as part of the music. But given the complexity of setup, and a culture not yet established (neither telephony engineers being prepared to transmit music nor musicians accustomed to playing over distance), the 'Hello?' moment was inevitable. And ultimately compelling for the audience. Before embarking on avant-garde improvised, noisy music where anyway one couldn't figure out who was playing what, or pick out a 'wrong note', that moment establishing contact was the moment of teletrust – creating the artistic contact between musicians, and authenticity for the audience beholding the moment.

The move from analogue POTS lines to digital ISDN brought some improvements and along with them some disadvantages. The digital data transmission of ISDN brought a significant jump in data bandwidth, up to 128 kbits/second (if two 64kbps lines were ganged together). There was a fundamental incompatibility between the US bandwidth of 56kbps with the 64kbps everywhere else in the world, causing 'Are you there?' headaches for our 1996 Paris-New York concert. Nonetheless, this bandwidth allowed for colour video up to 12 frames per second. However, the computational time needed for digitization and encoding and decoding and subsequent data transmission added delay (or latency) of one-half a second each direction, or one second round trip. While analogue telephony, even going through multiple telephone exchanges, sound travelled at the speed of light across continents. With digital telephony, latency became a new element, not to

be seen as a technical limitation, but as a sonic affordance to be assimilated musically, as part of what I coined to be the 'acoustic of the network' (Tanaka 2000).

There were two image quality settings on the early Polycom videoconferencing systems, 'clear' and 'smooth'. Clear refers to sending video at a higher pixel resolution (still QVGA or Quarter VGA, 320×240 pixels). Gaining in resolution came at a computational and data transmission cost, thus at a lower frame rate, as low as 2 fps. 'Smooth' meant foregoing resolution to gain framerate. HQVGA (Half-Quarter VGA, 240×160) gave more pixelized images, but that was sent at twice the framerate, creating more fluid motion (albeit blockier images). While the engineers setting up the equipment for us assumed we would want 'clear' to project the image large in the concert hall, the stuttering framerate took away from the musical flow. Instead, through trial and error, we found that we preferred seeing a flow of pixelized images of the performer at a higher framerate. The image became more abstract, but the flow was more musical, and more in sync with what was happening in the sound. We will return again to the question of sound/image synchronisation and abstraction later.

Alongside concerns about the flow of musicality, the staging of multiple perspectives of a network concert became an early concern. Even in the point-to-point connection of just two sites, this meant that there were two groups of musicians and two audiences. One set of musicians was remote from the other, but each had a local audience to entertain. Meanwhile, musicians needed to maintain eye contact to play together. What would be lines of sight through the mediation of camera, projector, network, screen, and hall? To maintain eye-to-eye contact with the remote musician meant for the local musician to look into the camera … the 'eye' of the remote site. However, if the remote musician were projected on screen, the camera and screen would need to be coincident. While this is today the default when a webcam is perched on top of a computer screen, a live presentation in a concert hall with a large screen, and some intent to create a proscenium presentation to the local audience of both local and remote musicians made this an impossibility. How could the live local musician and remote musician on screen be presented to the local audience? Where should the musician look to 'see' the other musician all while engaging their audience? We arrived at a triangulation of lines of sight (Tanaka 1999). While most stages setups use large screens behind the musician, making the remote musician larger than life scale with respect to the local musician, we preferred to use small screens, so that the remote musician could be projected alongside the local musician, at scale, side by side. By adjusting the diagonal and creating a triangle between the local performer, the remote performer and the local audience and positioning the camera between the audience and the remote screen (in essence the vertex opposite the local performer), the local musician could play to both far away collaborator and on-site spectator.

Twenty-five years later, the *Interwoven Sound Spaces* project (2022) of Federico Visi and Berit Greinke, connecting Piteå Sweden with Berlin Germany fulfils the challenge of scenography in telematic music performance (Visi et al., 2024). Each remote performer is displayed on a large screen display in portrait mode, alongside the local performer, at scale. They perform on an instrumented stage with interactive garments that capture and transmit performer gestures and movements in addition to sound. Visi and collaborators discuss how information from musical performance beyond just sound and image can be transmitted over distance, leading to a greater sense of remote presence and how

composers like Cat Hope respond directly to the system to imagine ways to address liveness (Visi et al. 2024).

Intimacy

The ISDN era brought with it a series of media art exhibition works. Many of them replicated the by then well known 'miracle' of communications from *Hole in Space* to a range of different configurations. The Quebecois artist Luc Courchesne created park benches connecting Francophone regions of Canada with France (Manovich 2003). Parisian artist Maurice Benayoun premiered his ambitious *Tunnel Sous l'Atlantique* at the Centre Pompidou in Paris connecting to New York (Benayoun 2015). A giant sculpture was like a tunnel entrance, plunging diagonally into the floor of the gallery, it was a huge viewing portal, where the light at the end of the tunnel was the equivalent situation on the other side. This illusion of a single arch is perhaps the perspectival revolution of telematic art. Where perspective gives a sense of depth and a third dimension to painting, the illusion of a direct tunnel humanises the distance and creates proximity of telematic audiences. Despite the illusion, and simplifidation of the labyrinthine path the telecommunication cables actually take, this brings an immediacy to the telematic public, helping to create a sense of teletrust across continents. For the moment, AT&T's advertising motto holds, and is strong enough to be the vehicle of deceptively simple artistic intent.

It was with Paul Sermon's Telematic Dreaming that ISDN art went beyond the simple hello to explore intimacies of virtual touch (Sermon 2000). The 'site' of Sermon's seminal work is not a park bench, nor a fake tunnel, it is a bed. Or two beds, one local the other remote, with the bed itself being the projection screen for the other. Whereas with our ISDN music concerts, we found a scenography of local and remote musicians side by side at scale in a triangle with the audience, Sermon explores superposition. Lying down on a bed, a participant becomes the remote performer on the faraway bed. And vice versa, the remote bedwarmer becomes a projection next to you on the bed on which you lie. The local and remote actors enter instantaneous intimacy, lying one alongside the other. Line of sight with the camera is no longer a question as was in a staged performance. The camera is all seeing. The subject sees the other next to them and can reach out to try to touch, to caress. We are projected into trusting the teletrust that's suddenly there – something perhaps more playful and innocent in the techno-utopian 90s than in today's cautious era of gaslighting.

More recently, I took part in a COVID response project by Paul Sermon and Randall Packer, *Pandemic Encounters* (*Pandemic Encounters* n.d.) (Figure 3). They brought together a roster of performance artists to perform cabaret style from their studio in the depths of lockdown. A sophisticated distributed video production studio was conceived by Packer that combined Skype and OBS bringing in traditional techniques like green screen to juxtapose actors from different sites and superpose virtual backgrounds. Each invited performer had a 10-minute slot to perform and transmitted their performance by Skype to command central (Packer's studio in Washington DC). Sermon, meanwhile in Brighton UK, would perform in a personal protective equipment (PPE) outfit on a miniature scale, as a kind of cabaret commentator MC. Everything was green-screened together

Figure 3. *Pandemic Encounters*, by Third Space Network and Paul Sermon. 2020 (photo: Third Space Network).

and broadcast as part of Leonardo's *LASER Talks* of online events. This pointed out the technical sophistication possible since *Telematic Dreaming*, and the professional tele trust that experienced performers instantly had to adopt in a tightness and temporality reminiscent of television production. But does this increased sophistication actually lead to enhanced teletrust?

Feedback and resistance

If *Telematic Dreaming* put in place the illusion and frisson of touch, it was in design work in 'tangible media' by Hiroshi Ishii that touch became a very real factor in creating forms of telematic empathy. *InTouch* (Brave, Ishii, and Dahley 1998), created by his team at MIT Media Lab, was deceptively simple and poetic. It had no pragmatic function or artistic pretense other than to transmit a sense of touch. Two rollers are connected by a wire. Each roller is crafted out of wood with precision mechanics/electronics, and invites the gallery visitor to roll the palm of their hand on it. When one person rolls their hand on one of them, the rollers on the other unit rotate, allowing a second person, gently placing their hand, to feel the actions of the first person. The interaction is a feedback loop, and the second person can themselves roll their hand on the other device, making their actions felt on the first. This simplicity belies a complexity not just in the engineering but in the instant social relation that is created. The feeling of remote rolling and the local input are additive. One could continue to roll in the same direction as what one feels. But if that then goes back to the other side, and your correspondent does the same, do the rollers accelerate out of control? Or, if you decide to roll in the opposite direction than what your friend is doing, you resist and contradict them. With what force (torque) does the roller 'insist'? Does this reflect either user's stubbornness or sheer exertion? Here, teletrust takes on a tangible dimension.

Inspired by seeing *InTouch* at the *Tangible Bits* exhibition at InterCommunications Center (NTT/ICC) Tokyo (Ishii 2007), I thought about sensing and actuation for my networked monochord, *Global String* (Tanaka and Bongers 2002) (Figure 4). The French composer, and bass player Kasper Toeplitz approached me, with the idea to 'create a giant bass guitar that goes around the world.' Combining insights in performance and staging gained from my ISDN concerts with Ishii's sense of remote reciprocal touch, I proposed to Kasper that we create a giant vibrating stringed instrument that spans two cities. As a duo, one of us would be at each end of the string, playing across distance. I proposed the work to Monika Fleischman, then at the Fraunhofer Institute IMK who would organise the CAST01 Mixed Reality conference where I would eventually meet Ishii. The work was supported by the Fondation Langlois (Plohman n.d.) and would be presented connecting Ars Electronica Linz with V2 Rotterdam (V2_, Eendrachtsstraat 10, and Rotterdam n.d.) and on a second iteration AEC and Trafo House Budapest. It was then exhibited in two rooms of the OK Centrum in Linz, allowing gallery visitors to understand that there were two ends to the string.

Global String is a hybrid musical instrument in several senses. It was real and virtual: physical steel cable in the gallery that disappeared into the ether to become dematerialised in the network to the other, physical side. It was for a concert performance by Kasper and I, and also an installation for the exhibition. It used sensing and actuating. Hitting it here would make it vibrate over there, and vice versa. The transmission time of data from

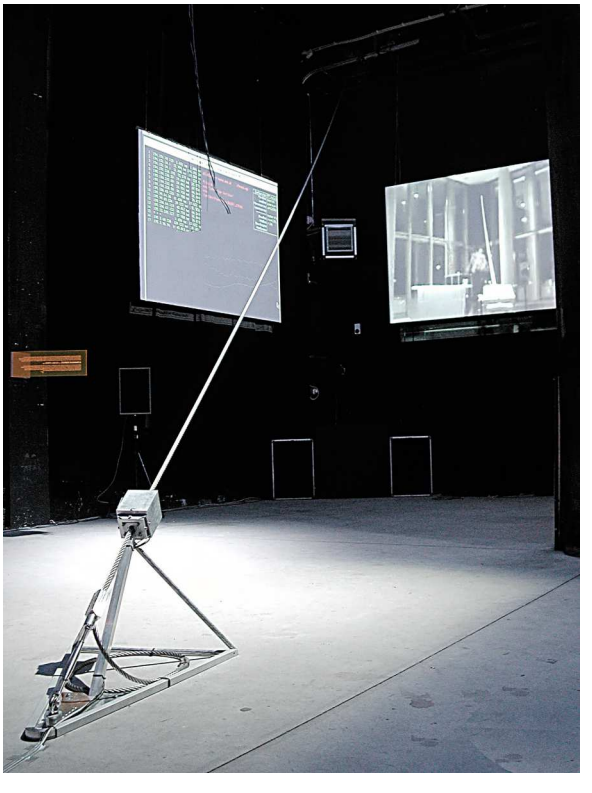

Figure 4. *Global String*, 2001, at V2_ connecting to Ars Electronica Center.

one end to the other was incorporated into the sound of the string, described below. This became the 'acoustic of the network', giving musical quality to the Global String as a vibrating string where its length was constantly slightly shifting depending on network traffic conditions. Network latency was not experienced as a lag or delay, but instead as a resonant quality of the musical instrument.

The steel cable is the endpoint of string, affixed to the floor of the gallery, raising up to the ceiling of the far wall. Two video projection screens surround the top of the cable. One shows a Unix *traceroute* readout reporting packet transmission times and the synthesised waveform. The other is a video stream from the other site. There, the camera is set up from the far end of that gallery, pointed towards the base of the string. This creates a visual continuity, a single arch for the monochord – local and remote as a single visual arch. This recalls the continuity Benayoun creates in the *Tunnel Sous l'Atlantique*.

Kasper and I would perform on the *Global String*, one on each end. The public on each side would see the local performer playing with the remote performer, much like in the previous ISDN concerts. Here we play on a single conceptual string, at times becoming a kind of tug of war. After the performance at the exhibition opening, the piece is left in installation mode, for gallery visitors to try. Here, serendipity enters the frame, as playing the string at any given moment depends on whether there is anyone on the other side. This recalls Sermon's *Telematic Dreaming*. Seeing someone playing on the remote screen invites a passer-by to engage and play on the local string. The vibrations representing the remote performance give a haptic sense of remote telepresence – the tangible teletrust of Ishii. While the long-distance set up (Linz-Budapest, Linz-Rotterdam) provided the same fascination as *Hole in Space*, we observed that setting up two ends of the string in two rooms of the same museum, as we did at OK Centrum (Offene Kulturhaus Oberösterreich) during the Festival Ars Electronica 2001 enabled gallery visitors to run from one end to the other – once they discovered this, friends could go to the two rooms and play together.

The sound of the string is generated by means of a physical model – a mathematical equation simulating the dynamics of a vibrating string, where the dimensions of the hypothetical string take on the distance between the two cities where the work was presented. With the 'length' of the string model to be hundreds of kilometers, the fundamental frequency of the string would be below the audible range. The other parameters: string stiffness and tension, were thus set very high in order to bring the vibration of the imaginary string into the audible range. Piezo sensors attached to the physical cable would pick up the players' touching, tapping, and scraping and use those noises as the excitatory stimulus for the physical model. People at each end of the string would intervene on the same physical model, thus playing together on one string, creating booming resonant sounds, as if striking the cables of a suspension bridge.

The movement in the sound came from the network traffic. The simple Unix command, *traceroute* was invoked to probe the path that each packet of network data took to get from one gallery to the other. The IP addresses of the network hubs, each gallery's Internet Service Provider (ISP), local and national gateways appear in the trace, along with the number of milliseconds each hop in the network adds to the delay, or latency, of the packet getting from one end of the string to the other. The delay time in milliseconds (hundreds of milliseconds by the time a TCP/IP packet traversed continental Europe), gave a temporal dimension to the synthesised sound. It was as if the actual length of

the string was varying ever so slightly according to network traffic. This added a time-varying component to the output of the physical model, creating a sound that came alive in its microvariation.

From point-to-point to networks

By 2010, the proliferation of high bandwidth Internet meant that the point-to-point and project-specific infrastructures for network music performance were replaced by general-purpose networks. Still, supporting bandwidth-intensive projects required specific initiatives, like Internet2 (CO-ME-DI-A n.d.), in response to which the AES whitepaper on network audio was written (Bouillot et al. 2009). Today this has been obviated by commodity fibre optic connections to the home, seemingly bringing sufficient bandwidth to stream movies at 4K resolution. However, despite increasing bandwidth, the essential network routing infrastructure of the Internet remains and continues to be incredibly robust. By prioritising packet fidelity over the time of delivery, however, real-time applications are always compromised. Data transmission protocols that forego error correction instead to prioritise rapid delivery, like UDP, are often used for time-based applications, but risk packet loss. While *Global String* used packet routing and ping times musically, these very real acoustic-of-the-network effects need to be addressed seriously. We also need to take into consideration the potentially divergent dynamics of sound and image.

A series of transnational network music projects, thus focused on high-quality low latency audio (CO-ME-DI-A). Jacktrip, created at Stanford's CCRMA made possible multi-channel, high quality low latency audio over networks (Renaud, Carôt, and Rebelo 2007) (Cáceres and Chafe 2010). These projects focused on musical interactions afforded by high quality and minimal delay. As such they were audio-only solutions. However, in public presentation, just hearing a remote performer, especially in high fidelity, does not provide the audience with a sense of distance. The fidelity that makes making music 'the next best thing to being there' for the musician ironically takes away the effort of distance witnessed in *Hole in Space*. What happens to teletrust when we no longer 'feel' the distance?

In presentations I attended, as an audience, of COMEDIA or JackTrip, a visual element was often added to show the remote performers and somehow reinforce their distance. However, video was often added as an afterthought and used a commodity service like Skype or Zoom. The care and rigour given to the audio were not afforded the visual. Perhaps as a musical performance, we could understand these decisions. However, this random juxtaposition of low latency audio with high latency video meant that there was a desynchronisation between sound and image. One of the key lessons we had learned with the Polycom systems back in the days of the ISDN concerts was to focus on framerate (rather than resolution) as a means to keep the connection between visual gesture and sound as tight as possible. To decouple sound from image, to transmit them over separate, independent channels, destroyed the perceptual coherence of the remote musical proposition.

In the *Hybrid Live* project, funded by the UK Arts & Humanities Research Council (AHRC) UK-US collaboration scheme, we worked with the JackTrip team and two cultural sector partners, Iklectik Art Lab in London and SFJazz in San Francisco, to look at how we could use the audio quality of JackTrip with some kind of visual representation that could keep

up with the low latency temporality of the sound (Tanaka 2021). We organised three showcase events in the two year project, first a concert of jazz duos in the classic ISDN concert staging setup, followed by electronic music and dance, where dancers in New York danced to music being played in London, to be seen by an audience at Iklectik in London.

We sought to keep JackTrip and its low latency high-quality sound. Rather than tack on video, we sought to develop a system that could transmit some visual representation of the same data transport. Encoding video, even at reduced resolution, creates a data-stream an order of magnitude greater than audio. In addition, the computational time required for encoding and decoding adds latency before sending and upon reception. (Part of the low latency performance of JackTrip comes from the fact that it is able to transmit uncompressed audio – think of WAV instead of MP3 – foregoing the data size reduction in favour of not losing any time whatsoever in the encode/decode process. However, its reliance on UDP protocol requires robust networks as there is no detection of packet loss.) We developed a computer vision system to perform skeleton tracking of the musician to then transmit only joint positions (head, shoulders, elbow, hands, hips, knees, feet). This radically reduced set of data representing musician movement then was piggy-backed onto the audio channel by means of frequency-shift key (FSK) modulation. This is a signal processing technique not dissimilar to the touch-tone sounds of pressing number keys on a telephone – combinations of frequencies and their shifting encoding information. The skeleton data was then transmitted as audio over JackTrip, taking advantage of its temporal qualities, and synched with the other audio channels carrying the sound played by the musician. Upon arrival, the skeleton data was rendered using shaders and 3D graphics techniques to create a ghostly, avatar-like representation of the remote musician.

Sharing

Despite the opening up of point-to-point connections of traditional and digital telephony by multi-node Internet architectures, telematic performance tends to subscribe to a broadcast model of media transmission. The transport medium is used as a means to relay audiovisual information from one site to another. Despite the commercialisation of streaming services where radio, television, and film are now conflated and obviated by on-demand streaming, these were later, sometimes awkward amendments to the original Internet protocol. Before today's ubiquitous streaming over HTTP was possible, experimental protocols such as Multicast, and Realtime Streaming Protocol (RTSP), in products like Real Player and QuickTime Wirecast, attempted to deliver video before the generalisation of high bandwidth fibre optic networks ('Real Time Streaming Protocol,' 2023). Internet radio was an active area of experimental media activity, with open-source streaming software like Icecast coupled with free encoder/decoder (codec) algorithms like Ogg Vorbis making broadcasting accessible to independent artists. Initiatives like Honor Harger and Adam Hyde's *Radioqualia* using early net-casting technologies to propose sonic content not typically heard on commercial Hertzian radio (Media Art Net 2023).

The revolution in Internet radio was not lost on traditional broadcasters. When I was approached by Südwestrunkfunk (SWR2) German radio, the discussion centred around

a commission for a hoerspiel (radio art piece) for radio and Internet. The producers imagined having me composer a *hoerspiel* that would be streamed on Internet radio at the same time as it was broadcast on traditional radio. For me, these two media didn't need to try to replicate one another – they each had their specific affordances. Radio broadcasts were extremely precise on time whereas Internet streams could be repeatedly listened to. Radio broadcasts were limited to the range of the transmission tower, whereas netcasts could be heard anywhere with Internet access. So Radio was time and space specific in a way Internet was time/space general. Relistening played on the Internet's archival, or information repository qualities. The radio was live. I sought, in my response to the commission, to imagine a work that could be a single composition that could have different modes of listening depending on the medium of access.

Meanwhile, I was interested in exploring the original promise of radio that had been curtailed in its standardisation and commercialisation. Bertholt Brecht imagined radio to be a two-way, participatory medium (Brecht 2015). Radio, for him, held the potential to realise the social and political vision of Epic Theatre. The development of radio from an experimental medium to a transmission medium is retraced by many historical texts, a recent one in which I participated as editor is Esther Leslie and Sam Dolbear's *Dissonant Waves* (Dolbear and Leslie 2023). While radio, by the time I received the SWR2 commission in 2002 was codified as a non-participatory unidirectional broadcast medium, I looked to the Internet side of my piece to open up the project to participation and interaction.

Prométhée Numérique / Frankensteins Netz is the resulting work, a hoerspiel for radio and Internet (Tanaka 2003) (Figure 5). It was premiered in a live broadcast during the Intermedium festival at ZKM in Karlsruhe in 2003 with telematic performances by Reiko A in Gifu Japan (IAMAS n.d.) and Zack Settel in Montreal. The libretto drew upon Mary Shelley's *Frankenstein*, Goethe's *Prometheus Unbound*, Lamettrie's *L'Homme Machine*, and Donna Haraway's *Cyborg Manifesto*. On the Internet it existed as a web-installation with an artificial life creature programmed by Antoine Schmitt that responded to user input, the compositional form of the score, and displayed text from the libretto as its skeleton, with its skin as renderings of images uploaded by network participants (Schmitt n.d.). While through composed in a notated score, it was open to the spontaneity of live performance and the vagaries of public participation.

This provided several different ways to listen to the work. The radio audience heard the live performance. A concert audience in the hall heard the same performance but through a multichannel sound system and visual representations of the remote performers and artificial-life creature as the fourth performer. The Internet audience had an interactive listening experience, zooming in and navigating by interacting with the A-life creature as a means to hear different parts of the mix. The work, through this channel, was complete only through the interaction of the listener.

The open participation by Internet spectators designed into *Prométhée Numérique* raised challenges in vetting uploaded content and commentary. The A-life creature, constituted initially of excerpts from the textual sources of the piece, needed to be 'fed' by input from a network audience to continue living. Following Shelley's novel, this creature was Frankenstein's monster, programmed with tools of the then still fresh digital era. The SWR2 radio, commissioners and producers of the work were extremely nervous about controlling the nature of uploaded content and insisted that all content be somehow

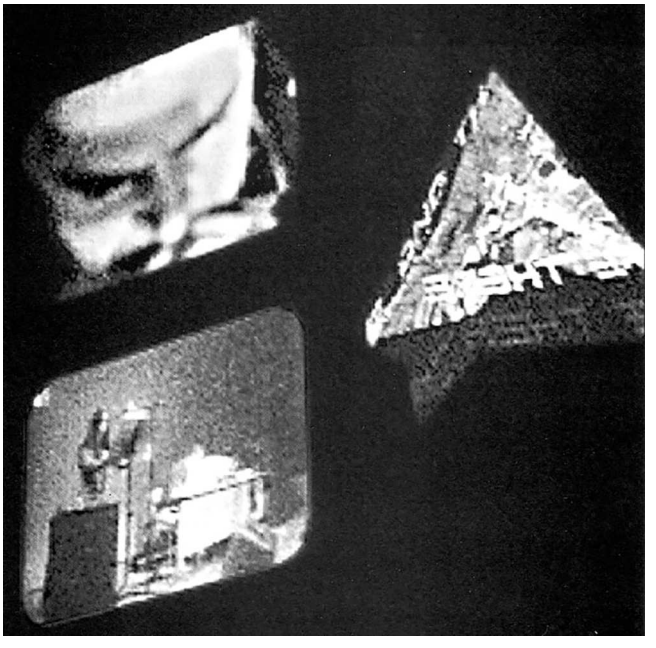

Figure 5. *Frankensteins Netz – Prométhée Numérique*, 2003, showing remote performers in Canada and Japan with A–life creature in Germany.

moderated before going online. As the artist received the commission and composed the work, an open form that explored the democratic potential of the Internet took primacy. Ultimately the outcome was disappointing for both parties. There were no harmful or incorrect text or images uploaded, as feared by the radio. On the other hand, most of the uploaded materials were utterly banal, disappointing the artist. It seemed that the magic of 'Hello are you there?' of the early works became diluted in meaningless, vulgar expletives of an Internet audience who did not take the time to engage with the interactive dynamic proposed by the piece and the software system underpinning it. This took place in 2003, before the social media explosion, the art of composing a 160-character Tweet or the narcissism of the selfie became part of the public consciousness.

Today, participatory social media has been generalised, and whilst the general public is accustomed to sharing random thoughts, photos of themselves or the food they are eating, these debates around vetting continue with questions of phishing, fake news and twisting questions of free speech. Perhaps, somehow in a politically innocent way, *Prométhée Numérique* was a harbinger of this new normal. In this way, it possibly fulfilled the second theme (and subtitle of Shelley's novel), of a 'Modern Prometheus' – then giving fire to humans without instructions of use, transplanted to the Internet as military-grade information technology deployed on an unsuspecting consumer base with no guidance on decorum or ethics.

In the twenty years since *Prométhée*, network participation, including by mobile phones has become widespread in musical and computational art works. In 2014, I was asked to respond to a new work by the media artist Rafael Lozano-Hemmer, his *Fiducial*

Voice Beacons, a permanent piece in the Science Museum in London for its then new Information Age Gallery (where the late Queen Elizabeth II inaugurated the gallery by sending her very first Tweet) (Bloomberg n.d.). The installation consists of forty interactive 'beacons' in the ceiling of the museum gallery. Each 'holds' a voice recording of a seminal figure in computer science Alan Turing, Ada Lovelace, Tim Berners Lee and others. Museum visitors are invited to download a mobile app to their phone that addresses each of the beacons. By selecting a beacon, the visitor enables it to light up, illuminating the gallery, and listening to the voice recording. In a participatory gesture recalling *Prométhée*, the visitors are then invited to record their own aphorism about the information age to upload and join the voices of the luminaries. In our invited response to the work, staged as a performance at the museum's Lates series, Steph Horak, Rebecca Fiebrink, Adam Parkinson and I brought in a quadraphonic sound system into the space, stood in corners of the space with a mobile phone in each hand conneted to the PA, 'playing' the beacons in a spatial sound mix (Singleton 2014). As for the participatory element, it is interesting to note that while the installation of beacons remains in the permanent exhibition in the Information Gallery, the Fiducial Voice Beacons app is no longer available on the Apple App Store.

Goni Peles brings network music performance and participatory collaboration into the present day by building upon gamer cultures (Peles and Adler 2023). In his *ScoreCraft* series of networked musical games, he uses the technologies and cultural practices of game live streaming and Discord chat as infrastructure for telematic musicking (Discord n.d.). Participants join an activity from their device by simply typing in a web address, connecting from their own network device. The Web Audio API (Smus 2013) accesses each participant's microphone, allowing them to interact by making sound. Features such as amplitude and frequency are extracted from user input and are used to control game elements, and gameplay tasks are provided for each activity – like moving through a labyrinth controlled by repetition of notes. They can be individual for competitive games, or aggregated, to have group activity summed to control one game item – like a projectile reaching its target. A concert mode streams a group of remote performers playing on their own musical instruments as inputs to *ScoreCraft*. This becomes like a chamber ensemble of game live streamers gaming musically. Watching a performance, the familiarity of gamer culture created an instant sense of tele trust amongst players and with the audience.

Utopian dystopias

From plain old telephone lines to gamer chat rooms, via ISDN and Icecast, networked music performance has traversed technologies and infrastructures over a half century. Notions of authenticity and trust are constructed and questioned, where the focus of the question shifts with the affordances of the supporting technology. The Electronic Café's *Hole in Space* can be thought of as the modernist moment – one where a simple Hello captures that moment in humanity. It is a Mcluhan-esque moment, where the artistic intent is imbricated in the transmission channel, where 'the medium is the message' (Mcluhan and Lapham 1994). Or to use Mcluhan's own riff on his aphorism, perhaps the medium is a *massage* (Mcluhan and Fiore 1967), where the instant teletrust we build saying hello soothes and reassures us confronted with the incomprehensible (and

today jadedly dark) consequences the technology brings forth. Was there a liveness and authenticity in *Hole in Space* that we assume but somehow miss with present day Skype and Zoom? Does the magic of connection give way to a supposed convenience that only now alienates us?

Telematic Dreaming takes us already to a critical post-modernist moment, problematising the seemingly instant intimacy network technologies incite us to, digital promiscuities and 'extimacies' – Lacan's notion of *extimité* (Lacan 2006). We are no longer massaged by the medium but think of the virtual or false massages the medium may implore us to make. This period of critical fascination gives way then to a long disappointment in democracy, as state radio seeks to retain control over incoming noise in my *hoerspiel* for radio and Internet. The 'undesirable' user generated content is not even worthy of censorship, it is merely information entropy (Shannon 1948). Perhaps by insisting on participation, just because the technology affords it, I unwittingly played into neoliberal exploitation of creativity (Tanaka and Parkinson 2018).

These early works were, in the 1990s and 2000s, exhibited in new venues for what was then called Media Art – Ars Electronica, ZKM, Transmediale. Whilst today they may be seen in today's postcolonial context as Western European institutions, in the day, they were utopian initiatives that sought to break down the hierarchies of the classical art world and open up creativity through the promise of the digital. The community of media artists, Sermon, Benayoun and others was an inclusive one. The Sónar festival was founded by the first generation of post-Franco dictatorship Catalans. Connecting with Japan was a gateway to opening up the experimental noise music scene to East Asia, Australia and the southern hemisphere. But today as these very technologies have been appropriated by platform capital, the early hope may seem naïve in retrospect. The post-dictatorship celebration through electronic music at Sónar has morphed thirty years later into one of the world's largest electronic music marketplaces, adding a tech innovation programme not unlike TED to become a sort of European SXSW. The digital, participatory element in Lozano-Hemmer's otherwise permanent work at the Science Museum London has disappeared from the app store and from history. Are these broken promises the 'artificial hells' Claire Bishop describes that results as a by-product of the instrumentalization of participation (Bishop 2012)?

Making it all a game, as *Scorecraft* does, puts music in conversation with other cultural forms. Or perhaps it is an admission that, to make the activity of music compelling to non-musicians, it's got to be made as easy as a game. By this point, we are in a post-Internet moment (Berry Slater, Farkas, and Archey 2015) where the net exists as a utility, like running water or electricity, and criticality, whether utopian or dystopian becomes displaced to blasé 'who cares'? The result is a kind of teletrust as escapism into play. Making trust palpable, then, comes through touch (Norman, Waisvisz, and Ryan 1998). If the telecom operators sold us remote telecommunications as the 'next best thing', touch may actually enable a form of 'being there.' Ishii's *InTouch* is the tactile *Hole in Space*, the modernist moment in reciprocal haptic interaction, where the message is the transmission and resistance of sensation. *Global String* explores the musicality in this duo play on a single string, a kind of mammoth, transcontinental bass guitar string as a form of Cat's Cradle.

Somewhere in the futility of participation and the promise of the tangible, there is a desire to fulfil, within music, new socialities afforded by network technologies, a form

of *musicking* (Small 1988). Utopian or not, there was a desire to respond to the democratising potential of network technologies as practitioners, as musicians interested in letting go of old hierarchies and total control. We wanted to mobilise modern communications technologies to fulfil Small's vision that all acts of engagement with music – listening, playing, concert going, are equally important aspects of the music itself. The telematic dynamics we have experimented with over the years are efforts with which we hope music reaches a kind of escape velocity to free itself of the shackles of hierarchical cultural production. In this way, telematic music is no different than any other music, it can build community, and therefore trust, across space and time.

Acknowledgements

The author would like to recognise the important involvement of Christine Tréguier and Pascal Schmitt (Les Virtualistes), Véronique Godé, Anne Roquigny in the organisation of our first network concerts, and participating artists including Camel Zekri, Edwin van der Heide, Christopher Coe, Fred Bigot (electronikat), Yuko Nexus6 and Elevator.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the UK Arts & Humanities Research Council (AHRC) under Grant AH/V009567/1 and AH/Y006054/1.

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Atau Tanaka (b. 1963 Tokyo) studied electronic music with Ivan Tcherepnin (brother of modular synthesizer designer Serge) at Harvard University. There he met John Cage during his Norton Lectures. Tanaka went on to carry out his composition doctorate with John Chowning and Max Mathews at CCRMA Stanford. He uses electrical signals from the body, the muscle electromyogram, to transform his body into the musical instrument. His solo work has been presented at Ars Electronica, ZKM, IRCAM, WOMAD, Sónar. His instrumental music has been performed by Ensemble Musique Nouvelles, Studio Artzoyd, and pianists Sarah Nicolls, Tricia Dawn Williams, Kathleen Supove and Giusy Caruso. His work in the Japanese avant-garde scene has been captured in the electronic music documentary, Modulations by Iara Lee, and exhibited at the San Francisco Museum of Modern Art and Musikinstrumenten-Museum Berlin. He has recorded releases on Superpang, SubRosa, Touch/Ash, and NX Records.

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