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Low-latency Networked Music Collaborations: Does "Good Enough" Do Enough Good?

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Low-latency Networked Music Collaborations: Does "Good Enough" Do Enough Good?

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Abstract

LoLa is a cutting-edge technology that enables low latency, real-time collaborations across vast distances using high-bandwidth, low-jitter networks. It has the capacity to transform how music is made and experienced. It has been utilized on a relatively small scale to date, primarily for teaching and performances associated with music colleges and concert halls. In this article we discuss various ways in which LoLa technology is "good enough" by describing examples of recent networked music performances "anchored" at Edinburgh Napier University, Scotland. We discuss the ways in which processes and outcomes were "good enough" for the sound engineer, participating musicians, and audiences. We then consider ways in which this work can be understood to have a social purpose and suggest further opportunities for putting this immensely powerful technology to use for the greater good. We argue that all who can utilize the potential of this technology have a responsibility to improve lives today and into the future.

Introduction: "Good Enough"?

Developments in technology happen at an ever-increasing pace, and at an ever-greater scale.[5] On a near-daily basis, new technological inventions are lauded for claims of assisting with increased productivity; these products are marketed to consumers for purposes of streamlining workflow or saving time.[6] Of course, it is in the interest of powerful agents of the capitalist system

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[5] Ida Engholm, "The Good Enough Revolution: The Role of Aesthetics in User Experiences with Digital Artefacts," *Digital Creativity* 21, no. 3 (December 2010): 141–154 , https://doi.org/10.1080/14626268.2010.488809.

[6] For more on the relationship between technological innovations and increased productivity, see Kevin J. Stiroh, "Information Technology and the U.S. Productivity Revival: A Review of the Evidence," in *The Best of* Business Economics*: Highlights From the First Fifty Years*, ed. Robert Thomas Crow (New York: Palgrave Macmillan), 279–290.

for consumers to relentlessly buy new technologies that will make their working lives more profitable and further enable them to spend more of their leisure time engaging in consumptive behaviours.[7] In this continual spiral of technological improvement, built-in obsolescence, and new product releases, there is rarely a paradigm shift in which users are provided with something truly novel. It is in the interests of company shareholders for products to *look* like they have undergone massive developments in order to entice consumers, and just as critical for their customers to never *truly* believe that a product is "good enough" since they might then be disinclined to buy the next upgrade.

Novelty often breeds positive attitudes toward adopting new developments, particularly ones associated with information technology.[8] When advancements are either sufficiently significant to impress people, or different enough to cause changes in thinking and behavior, there is an inclination toward positive appraisal of technologies and subsequent continued use. In a commercial context, if a technology is adopted widely enough (i.e., generates enough revenue) then this leads to a cycle of research and, ideally, improvements in functionality of a product. In the case of networked arts using LoLa—the primary focus of this article—the technology has been utilized in conjunction with universities, usually for research purposes or teaching master classes between well-funded institutions. While these situations have provided sufficient novelty and functionality for users to appraise tests with LoLa as "successful," the scope and impact of the projects have remained limited in scope and impact; this may not be "good enough" to provide impetus or incentive for future developments. In the examples offered above, the notion of "good enough" serves as a perceived barrier to the development of products that could be viewed as adequate by end users.

Precise and consistent use of terminology in this evolving area is still being developed by the community as practices become more widespread, better understood, and more fully conceptualized. For instance, Roy Ascott uses "networking" to describe networked activity and "telematics" for the medium as a whole.[9] For Ascott, telematic communication "replaces the bricks and mortar of institutions of culture and learning with an invisible college and a floating museum, the reach of which is always expanding to include new possibilities of mind and new intimations of reality."[10] Ivani Santana uses "networked" and "telematic" interchangeably to refer to

[7] For more on connections between capitalism, consumer behavior, and leisure, see Chris Rojek, *Capitalism and Leisure Theory* (London: Routledge Revivals, 1985); Robert A. Stebbins, *Leisure and Consumption: Common Ground/Separate Worlds* (London: Palgrave Macmillan), 1–29, https://doi.org/10.1057/9780230244863.

[8] For more on newness and technology adoption, see John D. Wells et al., "The Effect of Perceived Novelty on the Adoption of Information Technology Innovations: A Risk/Reward Perspective," *Decision Sciences Journal* 41, no. 4 (Nov. 2010): 813-843, https://doi.org/10.1111/j.1540-5915.2010.00292.x.

[9] Roy Ascott, "Art and Telematics: Towards a Networked Consciousness," in *Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness*, ed. Edward Shanken (Berkeley: University of California Press, 2003), 188.

[10] Roy Ascott, "Concerning Nets and Spurs: Meaning, Mind, and Telematic Diffusion," in *Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness*, 201.

distributed arts practice via the internet.[11] Members of this authorial team have described practices similar to those outlined in this paper as "real-time, remote, interactive" music-making sessions.[12] Throughout this paper we use the terms "networked music collaboration" and "networked music performance" to refer to music-making undertaken simultaneously by practitioners in multiple locations, facilitated by use of internet applications and hardware.

While early concerns in networked music collaboration circles were primarily technical, the focus in the community is now increasingly on social issues. As the technology is now technically adequate in many ways, we are able to turn our attention to the impact of distributed, collaborative practice. Networked music performance has arrived at a position where the notion of "good-enough" could lead to a decline in the rate of progress required to make the technology fully functional and user friendly. In this paper, we explore the proposition that those of us operating in networked music performance have a responsibility to ensure that being "good enough" also means doing "enough good."

In this article, we examine examples of networked music collaboration using LoLa technology from three perspectives: first, from the perspective of a recording engineer, then from musicians, and lastly (and more briefly) from audiences. Paul Ferguson is an academic and recording engineer with an industry background in network-based communications research and development. Since taking part in the United Kingdom's first trial of the LoLa system in 2012, Ferguson and Gill Davies, a multimedia producer and director of the networked arts production company GDP, have researched the use of low-latency audio and video streaming for real-time remote participation in master classes, rehearsals, and performances between the United Kingdom, Europe, and the United States; several of these networked music collaborations will be discussed below. In 2016, Zack Moir and Gareth Dylan Smith joined the research team; their work has focused on examining real-time studio recording over distance.[13] Zack Moir is an Associate Professor of music, as well as a saxophonist and composer, with a strong interest in music education and social justice. Together with Gareth Dylan Smith—a drummer and recent emigrant from the United Kingdom to the United States—their scholarship considers how music-making practice intersects with considerations of how the personal enjoyment and relatively low-impact of networked music collaboration might lead to potential benefits on a larger scale. Woven throughout is critique drawn from the recognition that more needs to be done to improve various aspects of work in this area. We

[11] Ivani Santana, "Networked Dance Performance: A New Temporality," *Liminalities: A Journal of Performance Studies* 10, no. 1 (May 2014): 2–19, http://liminalities.net/10-1/new-temporality.pdf.

[12] Zack Moir et al., "Real-Time, Remote, Interactive Recording Sessions: Music Production Without Boundaries," in *Producing Music: Perspectives on Music Production*, ed. Russ Hepworth-Sawyer, Jay Hodgson, and Mark Marrington (New York: Focal Press, 2019), 194.

[13] For more on research into real-time studio recording over great distances, see Zack Moir et al., "Real-Time, Remote, Interactive Recording Sessions: Music Production Without Boundaries," in *Producing Music: Perspectives on Music Production*, ed. Russ Hepworth-Sawyer, Jay Hodgson, and Mark Marrington (New York: Focal Press, 2019), 194–208.

conclude with considerations of the broader social purpose of technological progress in networked music collaborations, including what those with the power to do so, could and arguably should be doing to ensure that technologies with such incredible powers of social connection go beyond being "good enough," to beginning to do "enough good." Academics—including members of this authorial team—have a particular moral obligation to do more, especially given how public funding of many higher education institutions effectively makes us civil servants.

A Recording Engineer's Perspective on Networked Music Collaboration

In this section we explore the notion of "good enough" through descriptions of three LoLa sessions that were engineered by Paul Ferguson. These sessions were held from July to September 2019. Example one was a LoLa master class and teaching demonstration at the Royal Conservatoire of Scotland's Learning and Teaching Conference. Example two was an 18th birthday special edition of the British Broadcasting Corporation (BBC) radio program *Digital Planet*. This was a "live" broadcast on the BBC World Service, with the LoLa demonstration taking place in front of an audience at the BBC Broadcasting House Radio Theatre in London, England. Streaming teams from the Royal College of Music and Edinburgh Napier University worked with BBC research and development staff and BBC audio engineers. Example three was the "Global Brass Live" concert, organized as part of the Durham Brass Festival. In this concert, two brass bands—one located inside the Gala Theatre in Durham, England, and the second at the Royal Danish Academy of Music in Copenhagen, Denmark—played a two-hour program to a paying festival audience. We then discuss further instances in which we facilitated distributed performances using LoLa, including a 2015 master class with the Hebrides Ensemble chamber group and the 2018 and 2019 Armistice Centenary #iPlay4Peace concerts.

The master class, our first example, required a single operator at each end to be responsible for the LoLa camera, lighting, and microphone placement. The operator was also responsible for monitoring the network connection and assessing packet loss versus resolution and frame rate. Available bandwidth was low, so the demonstration ran with compressed video requiring 25 Mbps. Ferguson has described this experience as one that reframed his sound engineering role, further diverting his attention away from sonic and aesthetic considerations. While the teacher delivering the master class described the video quality as being adequate, packet loss introduced clicks into the audio; this was understood and accepted by the participants. Both teacher and students reported a very positive learning and teaching experience.

In example two, the BBC broadcast, the "good enough" bar was raised through pressure to deliver a live international broadcast. In this example, the team included a research and development engineer from the BBC who was responsible for the network connection, allowing Ferguson to focus on conventional sound-engineering responsibilities. While packet loss was low,

there were still audio clicks, but these were felt to be acceptable since the television program was about the technology, rather than the aesthetic of a finished product or artwork. Although this was a radio production—and the emphasis was on audio—the live audience at the BBC Broadcasting House Radio Theatre was required to see the remote performer. The BBC's producers stipulated 720p video at 25 fps; here, the bandwidth requirement increased ten-fold from the master class. Time constraints imposed by the program schedule precluded any measures such as audience microphones or a separate camera feed of the audience. As a result, the remote performer's sense of immersion in the BBC radio theatre was minimal. In the section that follows, we discuss performer experience in more depth.

Example three, the Durham Brass Festival, stands out in terms of our "good enough" threshold. This was a festival concert with a ticket-buying audience and, although novel—believed to be the first time this technology has been used within the professional brass band community—it was a two-hour concert performance first and foremost, rather than a demonstration of technological capability. The Danish and British brass bands were made up of experienced performers; they found that the network-induced audio clicks occuring during rehearsal prevented them from playing to their usual standard. Technical staff at the Gala Theatre in Durham and Durham City Council's IT specialists worked against the clock; they discovered that an intermittent transceiver fault was causing packet loss. They were then able to establish a reliable route to the Janet Network, the United Kingdom's national research and education network (NREN). Single cameras were used in Copenhagen and Durham. These were situated so as to afford members of each group a sense of being somewhat co-located with the remote performers; however, the sheer size of the ensembles meant that any sense of immersion was still somewhat superficial.

The bandwidth requirement for example two was higher than that of the early demonstrations of LoLa that began in 2010. This is because video quality can now be high-definition (HD) and audio can be multichannel rather than just stereo; these improvements demand more bandwidth as well as faster computers with six or more cores. The move from standard-definition video and CRT-based monitors to HD video has also added latency, coming from LCD and LED screens and projectors themselves. Overall end-to-end latency is something that requires closer examination within the LoLa community. When discussing the latency between distributed musicians, we typically quote the time reported by the LoLa "software check" button which is the result of a network echo request/reply message sequence, commonly known as a "ping." However, this figure is only part of the actual delay; in addition to the ping time, we should add the time taken for audio ingest, processing, and output. The total figure will also be increased if the LoLa audio buffer value is not zero. In practice, the round-trip figure experienced by musicians playing between Edinburgh and London could be between 20 ms and 30 ms, rather than the 10 ms reported per ping.

The error between actual latency and the ping figure is even greater for the video path. We must add any latency added by the monitor or projector, plus any video switcher in the path. This can be minimized by using fast gaming monitors, though at the cost of image size. We found that

large, 55-inch television screens and projectors add a minimum of one frame of additional processing time, equated to 33 ms at a frame rate of 30 fps. If we add this additional, 33-ms frame to LoLa's (impressively fast) 20-ms video input-to-output time, the video latency is actually 53 ms, plus any network time. Compared with the 5 to 10 ms for audio, audio and video are out of sync.

At the 2013 TERENA networking conference, Steve Waterman played trumpet in Edinburgh, Scotland with a jazz quartet in Maastricht, Netherlands. During rehearsals, a saxophonist in Maastricht described Waterman's performance as "dragging." As an experienced orchestral brass player, Waterman had experienced this phenomenon in previous work using LoLa, equivalent to the approximately 1 ms-per-foot time delay introduced by the distance between him and the conductor. Waterman played ahead of the beat as he would in the orchestral situation and thus corrected the timing issue with the saxophonist. This was the first international performance to use LoLa with multichannel rather than stereo audio. The availability of eight audio channels allowed audience mics to be deployed in Maastricht, which Waterman reported as giving him a sense that he was playing a live gig with an audience, despite being a solitary performer in an Edinburgh recording studio.

A distributed concert entitled #IPlay4Peace took place on November 11, 2018. Held on Armistice Day, the event commemorated the 100th anniversary of the World War I ceasefire agreement between the Allied forces and Germany. The "anchor" concert took place at Edinburgh Napier University, on the site of the former Craiglockhart War Hospital where the wartime poets Wilfred Owen and Siegfried Sassoon recuperated. Unlike our earlier LoLa projects, this concert also featured more conventional one-to-many streaming via YouTube. "Armistice," a composition by violinist Thoren Ferguson, was central to the global concert; in advance of the event, the score and a demo audio recording (for those who wanted to hear, rather than just read the music) were shared over social media with public so people could join in if they desired. While an Edinburgh-based string quartet from Tynecastle High School joined the 50 piece orchestra from George Watson's College (a public school in Edinburgh) in real-time using LoLa, most players were spread across 45 sites in 10 countries: South Africa, Turkey, Kosovo, Albania, Belgium, Italy, China, Luxembourg, the United States and the United Kingdom. These remote sites featured individual performers and small ensembles playing in satellite concerts with their own audiences. At 3:00 p.m. central European time, the remote performers came together to play with the Edinburgh anchor concert orchestra performance, "virtually" conducted by David Elliot from George Watson's College who appeared as a picture-in-picture insert in the YouTube live stream broadcast.

For author Paul Ferguson, numerous aspects of the Armistice commemoration concert were not "good enough." (His perspective is shaped by his work as an audio engineer researching real-time performance since 2012.) Areas in need of improvement included the quality of compressed audio, performer immersive experience, and latency—the latter was measured in seconds, rather than milliseconds. Nonetheless, of the projects to which he has contributed, he reports that it was

perhaps the one that achieved the greatest social good. Facebook comments from participants made clear that over 100 of the performers found the event to be a significant, shared musical experience. It was also the subject of a motion to congratulate in the House of Commons raised by the Right Honourable Frank Fields, MP, indicating that the event was officially recognized as having achieved some substantial level of social good in the United Kingdom, at least.

The success of the global element in the 2018 Armistice #iPlay4Peace concert led to a follow-up 2019 Armistice Day concert. Looking ahead to the future of such performances, would it be sufficient to follow the same model, or would the experiential bar need to be raised? Certainly, the Tynecastle High School musicians had a different experience from other participants as they were playing in real-time using LoLa. The opportunity to try something different was afforded by the acceptance of Edinburgh Napier University as a satellite site to the main NowNet Arts conference based at Stony Brook University. For the conference, Edinburgh, along with the other conference satellites in Los Angeles, Ghent, and Berlin, had "always-on" Zoom and JackTrip connections to Stony Brook, giving us multi-located, real-time possibilities on Armistice Day. For any future Armistice concert "anchored" in Edinburgh, will it be possible for remote sites to stream their concerts over social media to be viewed by a global audience and also be incorporated—albeit video only, due to the large latency—into the livestream from Edinburgh? Would this be "good enough," and for whom? In terms of doing enough good, any future iterations of Armistice Day concerts would inevitably fail to live up to the successes of the 100th anniversary event; it was an especially emotive event on a particularly poignant day, having coincided with numerous national and global remembrance events.

Networked music performance practice via LoLa brings with it numerous technological challenges. For instance, 1 Gb connections to national research and education networks (NRENs) are not available in a number of higher education establishments—even when a 1 Gb network may be available, "last mile" connectivity is still a problem. With GÉANT, which connects NRENS across Europe, network paths are not always direct; this introduces levels of latency unsuitable for synchronous networked music performance. Competing traffic on networks has to be taken into account as well. Issues with network connectivity, including the existence of firewalls and other traffic-shaping software, highlight the advantage of having a research team, such as we do at Edinburgh Napier University, that includes a dedicated network engineer.

Another persistent challenge with LoLa is providing sound monitoring for participating musicians. Foldback through loudspeakers provides the local musician with remote artist instrument sound and talkback mic, together with room ambience and audience mics if available. The local musician is also able to hear any local sound emanating from the room in which they are playing. With in-ear monitors (IEMs) or headphones, the mix can include remote artists' instruments and chat mics, plus any room ambience and audience mics. This mix can be supplemented with a contribution from local microphones mounted on or near the IEMs or headphones. In the near future, we have plans to investigate a potentially interesting hybrid of

speakers and IEMs. Here, a remote artist's sound would be fed directly to the IEMs but the remote ambience and audience noise would come to loudspeakers to be indirectly picked up by the IEMs or headphone microphones. Using this hybrid approach, the stereo room cues would pan correctly as the local artist moved their head; we anticipate, therefore, that the local artist would not experience total disconnect from the remote environment when IEMs or headphones are removed, something that this team previously identified as a challenge.[14]

Performers' Perspectives on Networked Music Collaboration

As Ascott has noted, "telematic art is conceptually driven, not technologically led."[15] As such, practitioners in real-time, remote interactive music-making tend still to think in terms of replicating a traditional performance, facilitated through new technological means. However, this is a new form of art: It has been theorized as "deterritorialized...decentered," "multi-located," and occurring in a third space or "third room."[16] Much more consideration has to be given to the aesthetics of live performance in this new, hybrid environment.[17] Nonetheless, in order for artists to work on concepts and aesthetics, the technology needs to be operated seamlessly to realize both artists' and technologists' intentions.

A key challenge when engaging in real-time networked music performance is latency and the impact it has on musical timing, musical interaction, and social connection.[18] Chafe notes that

[14] Zack Moir et al., "Real-Time, Remote, Interactive Recording Sessions: Music Production Without Boundaries," 194–208.

[15] Roy Ascott, "*Telenoia* Announcement," in *Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness*, ed. Edward Shanken (Berkeley: University of California Press, 2003), 282.

[16] For more on conceptual and practical aspects of "deterritorialized," music making, see Joseph Michael Pignato and Grace M. Begany, "Deterritorialized, Multilocated and Distributed: Musical Space, Poietic Domains and Cognition in Distance Collaboration," *Journal of Music, Technology & Education* 8, no. 2 (July 2015): 111–128; for more on "multi-located," see Margaret C. Rodman, "Empowering Place: Multilocality and Multivocality," *American Anthropologist* 94, no. 3 (September 1992): 640–656; and for "third room," see Zack Moir, Paul Ferguson, and Gareth Dylan Smith, "Jamming in the Third Room" (presentation at 11th Art of Record Production conference, Copenhagen, Denmark, December 2, 2016).

[17] For more on aesthetic considerations in the hybrid live / multi-located environment, see Zack Moir et al., "Real-Time, Remote, Interactive Recording Sessions: Music Production Without Boundaries," 203–205.

[18] For recent literature on the subject of latency challenges in networked music performance, see Alain Renaud, Alexander Carôt, and Pedro Rebelo, "Networked Music Performance: State of the Art," in *Proceedings of the AES 30th International Conference* (Saariselkä: Finland: AES, 2007); Gil Weinberg, "Interconnected Musical Networks: Toward a Theoretical Framework," *Computer Music Journal* 29, no. 2 (Summer 2005), 23–39, https://doi.org/10.1162/0148926054094350; Chris Chafe, "Living With Net Lag," in *Proceedings of the AES 43rd International Conference* (Pohang, Korea: AES, 2011), 1–4; and Alexanderr Carôt and Christian Werner, "Network Music Performance—Problems, Approaches, and Perspectives," in *Proceedings of the 'Music in the Global Village' Conference* (Budapest, Hungary, 2007), http://www.carot.de/Docs/MITGV_AC_CW.pdf.

latency can be "ignored, tolerated or exploited."[19] Davies observed most musicians found their playing slowed down during faster sections, resulting in a recursive drag.[20] To cope with effects of latency, some musicians isolated faster sections and practiced those together in an effort to play together synchronously during rehearsals. In performance, however, musicians were able to play together effectively, suggesting that they were able to shift from "network lag difficulty" to "concert-making mode."[21] More experienced musicians were able to apply mechanisms used to deal with latency in traditional music practice to networked music collaboration. For instance, Steve Waterman, the trumpeter in the Maastricht master class, noted that although he opted to use IEMs instead of a floor monitor, he felt disconnected from the concert unless he was in front of a microphone and wearing his IEMs. At that point, he found it difficult to communicate with the technical team around him in Edinburgh, leading him to break the seal the IEM was making in the ear canal to allow ambient sound to enter. A similar clash between the experienced realities of remote and local spaces is described by a drummer in London playing with a duo in Edinburgh.[22] Musicians' tolerance of latency may depend on their perception and on performance speed, as well as on their experience and the instruments they play.[23]

The 100th anniversary Armistice Day concert in 2018 raised conceptual and practical issues in terms of networked music performance. Unless the loop was closed to bring those remote contributions back to Edinburgh, it could be argued that, for the event's musicians and audience, it was simply a streamed broadcast and not a networked performance. However, one could make the case that the loop *was* closed—albeit not in real-time. Although the participants in the Edinburgh anchor concert were unable to know how many remote musicians were actually playing along with the livestream at 3:00 p.m., the concert's #iPlay4Peace Facebook page had enabled those involved to see the development of satellite concerts in South Africa, Italy and Turkey, for example, during the weeks leading up to the concert.[24] As a result, participants in those satellite venues could be acknowledged during the concert's streamed opening speeches and welcomed by

[19] Chris Chafe, "Living With Net Lag," in *AES 43rd International Conference* (Pohang, Korea: AES, 2011), 1.

[20] Gill Davies, "The Effectiveness of LOLA (LOw LAtency) Audiovisual Streaming Technology for Distributed Music Practice" (MA thesis, Edinburgh Napier University, 2015).

[21] Chris Chafe, "Living With Net Lag," in *AES 43rd International Conference* (Pohang, Korea: AES, 2011), 4.

[22] Zack Moir, Paul Ferguson, and Gareth Dylan Smith, "Jamming in the Third Room" (presentation at 11th Art of Record Production conference, Copenhagen, Denmark, December 2, 2016).

[23] For more on how performance speed affects latency, and individual perception of latency by musicians themselves, see Alexander Cârot and Jason Reizner, "A Telematic Approach for Mass Music Ensembles," in *Conference Proceedings (Re-New Digital Arts Forum)* (Copenhagen, Denmark: Re-new, 2013), 170–174, https://issuu.com/re-new/docs/re-new_2013_conference_proceeding; for more on the effect of instruments on how musicians perceive latency, see Gill Davies, "The Effectiveness of LOLA (LOw LAtency) Audiovisual Streaming Technology for Distributed Music Practice," 2015.

[24] As of the date of publication, the #iPlay4Peace 2020 Facebook page remains live, https://www.facebook.com/groups/1943453119253628/.

the Edinburgh audience. As they did not appear in the livestream, the remote musicians (for example, those playing from South Africa) lacked audio or video confirmation that they were playing in the concert. In the hours following the concert, comments and video clips began to appear on the #iPlay4PeaceFacebook page that demonstrated that the level of participation extended across the 45 locations. These video records of the remote performances were then edited into video footage from the anchor concert to provide an historical record documenting the global collaboration missing from the original livestream—thus, the participation loop for performers was closed.

Another issue arising for performers in networked music performance is how to create "sonic realism," despite the remote location of co-performing musicians. For instance, in a master class with the Hebrides Ensemble, an attempt was made to improve the perceived realism of the remote French horn for ensemble members in Edinburgh; in order to do so, front and rear remote mics were fed to corresponding front and rear-facing loudspeakers that were placed where the instrument would normally be when the horn player was part of the ensemble. The ensemble's leader, cellist William Conway, was the most convinced by the attempt at sonic realism. Sitting next to the virtual horn player, he was able to hear the remote player's breathing, which contributed to his engagement. Of this experience, he said, "I didn't need to watch to be with him."[25] Conversely, the experience was negatively reported by the horn player giving the master class. Early in the session he commented on the poor synchronization between audio and video, resulting in him focusing on sound more than visuals.

The low-latency video stream is a potential massive benefit for networked performance offered by LoLa and CESNET 4K Gateway—something not possible prior to the development of these technologies. Nonetheless, scholars such as Franziska Schroeder have argued that the lack of *direct* visual contact with remote partners in improvised networked music performance requires musicians to listen in a different way, in which "the ear is urged to be less static."[26] In earlier research, Schroeder et al. have found that musicians in both score-based and improvised networked music performances rarely looked at the frontal perspective of remote players because the set-up was unnatural in that performers would not stare at one another face-to-face while playing together in a physical space.[27] Rather, performers communicate with one another more subtly, as they do not require a full representational presence of another player in networked

[25] Gill Davies, "The Effectiveness of LOLA (LOw LAtency) Audiovisual Streaming Technology for Distributed Music Practice," 2015.

[26] Franziska Schroeder, "Networked Listen[ing]: Exploring a Haptic Aurality," in *Performing Technology: User Content and the New Digital Media: Insights from the 2000 + NINE Symposium*, ed. Franziska Schroeder (Newcastle upon Tyne, UK : Cambridge Scholars Publishing, 2009), 126.

[27] For more on performer gaze and co-location in physical space, see Franziska Schroeder et al., "Addressing the Network: Performative Strategies for Playing Apart," in *International Computer Music Conference* (2007), 113–140, http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.521.3054.

music performance. Schroeder et al. also take the view that users of videoconference technology tend to place too much emphasis on the notion of "being there," thus impeding exploration of "being apart."[28]

A study at the Royal Danish Academy of Music showed that the more similar videoconference lessons were to face-to-face lessons, the less impact the technology had on teacher-student interaction.[29] A violinist participating in networked music performance practice with a LoLa team in Trieste, Italy found it beneficial that the screen showing the remote pianist was placed beside the piano in the Edinburgh studio; the specific placement allowed him to suspend his disbelief that she was not in the same space, particularly when the picture quality was in HD and he could see reflections of his own image in the glasses of a member of the LoLa team in Trieste. Musicians in the jazz quartet in Maastricht noted that they had to turn their back to the audience to view the projected image of the remote trumpeter and said it would have been more effective if his image had been placed where he would be situated in a traditional stage performance. The drummer in this instance did not have a clear view of either the projected image or the monitor screen; because of this, he defaulted to using his ears. This was also the case for Hebrides Ensemble musicians when the discrepancy in latency between audio and video resulted in visual delay. Eye contact was cited as problematic across examples, as musicians' eyes were drawn to looking at the screen, rather than the LoLa capture camera above the screens. Musicians reported that this caused a feeling of disconnect from remote performers. Furthermore, screen size impacted the connection between distributed musicians; while a smaller screen introduced less latency, it gave musicians a restricted view of remote partners, thereby impairing the sense of connection.

Justin Trieger has highlighted how the etiquette of collaborative networked music practice is not yet fully defined. Speaking at a masterclass of his own, Trieger has said:

> In a masterclass scenario or a coaching session, it is not just a case of switching on the computer and launching straight into a lesson. There has to be an understanding between participants, and teacher and students should feel comfortable. Therefore, participants should introduce themselves and discuss their background before the lesson begins.[30]

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[28] For more on the need to explore "being apart" in distance collaborations, see Franziska Schroeder et al., "Addressing the Network: Performative Strategies for Playing Apart" (2007), http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.521.3054.

[29] Karin Levinsen, Rikke Ørngreen, and Mie Buhl, "Telepresence as Educational Practice in the Third Teaching-room: A Study in Advanced Music Education," in *Proceedings of the European Conference on E-learning*, ed. Mélanie Ciussi and Marc Augier (Sonning Common, UK: Academic Conferences and Publishing International, 2013), 252.

[30] Justin Trieger, "DVTS Masterclass Demonstration" (presentation, Network Performing Arts Production Workshop 2013, Academy of Music and Performing Arts, Vienna, March 13, 2013).

Trieger suggested connecting with distributed partners or tutors on social networks in order to learn more about one another in advance of a networked session, as happened with the aforementioned Armistice centenary concert. At the Network Performing Arts Production Workshop in 2015, dancers from Liverpool John Moores University said getting to know their remote partners in Florida through social networks helped them bond even though they were thousands of miles apart.

Both Hebrides Ensemble players and jazz musicians in Maastricht reported that their sense of the presence of the remote performer would have improved if the image were in three dimensions. One violinist found the biggest difference between traditional and networked music performance was that in a traditional performance he would rely on three-dimensional physical input to gauge emotional responses of co-sited musicians. Davies showed that while some musicians said their experience of LoLa improved when camera capture was in HD at 60 fps, previous studies showed that when displaying remote musicians on a screen, musicians found the use of technology—and the fact that collaborating performers were located remotely from one another—to be far more pronounced.[31]

Audience Perspectives on Networked Music Collaboration

While a screen view may be functional and even desirable for master classes and rehearsals—where the focus is on the quality of music, getting to know a remote partner's playing style, and even blending as an ensemble—it is perhaps less suitable for a performance in front of an audience. As Miller Puckette says, "It is the television; how is an audience to know that the remote performer is live and not simply video that has been recorded prior to the performance?"[32] In larger venues, many audience members watch performances on a screen if they are seated far from the stage. Also, Bob Giges and Edward C. Warburton observe that when distributed performers are not in sync, audiences see "latency made manifest" as proof that the event is live.[33]

Audiences at events using LoLa technology noted sound quality as the most important factor in their enjoyment of a networked music performance. Audience member comments on social media showed that the presentation of the remote jazz trumpeter in Maastricht was effective; he appeared to be more integrated with the live performers than in previous networked

[31] For more on musicians' experiences with using LoLa, see Gill Davies, *The Effectiveness of LOLA (LOw LAtency) audiovisual streaming technology for distributed music practice*. Unpublished master's thesis, Edinburgh Napier University, 2015), 61.

[32] Miller Puckette, "Not Being There," *Contemporary Music Review* 28, no. 4–5 (2009): 410, https://doi.org/10.1080/07494460903422354.

[33] Bob Giges and Edward C. Warburton, "From Router to Front Row: *Lubricious Transfer* and the Aesthetics of Telematic Performance," *Leonardo* 43, no. 1 (February 2010): 30, https://doi.org/10.1162/leon.2010.43.1.24.

performances. Audience members present at a distributed clarinet quartet performance said they missed the interaction between players. For them, the fact that the LoLa capture camera offered only a static locked-off shot of the remote musicians restricted the way in which they could be presented creatively; this, in turn, impacted audience perception of performer interactions with each other. The majority of musicians participating in networked music performances where there was no audience present cited this as a disadvantage, as audience reaction determines to some extent how they play. This is perhaps particularly the case for jazz musicians, who noted that the audience is almost another member of the band. To improve the playing experience for Waterman, the jazz trumpeter in Edinburgh, he was given a feed of the sound of the remote audience. He reported that this made "a huge difference," as it allowed him to create the feeling that he was playing in front of a live audience. Etiquette of networked music performance is another important consideration. For instance, Waterman led the performance and introduced each piece, which was effective in highlighting his presence for the audience at Maastricht and creating a sense of unity among the distributed musicians.

Networked music performance, then, affords musicians and audiences numerous possibilities, as well as bringing with it some notable challenges. Moreover, Ascott argues that a radical shift in thinking is required within older cultural institutions in the post-digital age, in which conceptual and applied foci shift away from the primarily technological towards the more human and social, to "guarantee public involvement and cultural viability."[34]

Is "Good Enough" Doing Enough Good?

Due to specific technological requirements and the nature of employment and funding opportunities in the arts and higher education, to date, LoLa has been housed in and operated primarily by the university sector.[35] Access to Internet2 is expensive and primarily used by academics working in scientific fields in the United States.[36] Dip Kapoor and Steven Jordan suggest that "to think that the physics department will buy the music department a new gigabit router, and pay to rewire the concert halls with fibre, seems like pipe dreaming"; however, while universities and colleges doubtless serve as incubators for applications of developing and emerging technologies, it is surely incumbent upon these institutions to share their "good" in and

[34] Roy Ascott, "Telenoia," *Telematic Embrace*, 266.

[35] For more on funding arts in the higher-education sector in England, see Gareth D. Smith, "Doublespeak in Higher Music Education in England: Culture, Marketization and Democracy," in *The Routledge Handbook of the Sociology of Music Education*, ed. Ruth Wright, Geir Johansen, and Patrick Schmidt (New York: Routledge, forthcoming).

[36] Internet2 can be seen as the U.S.-based equivalent of Janet, connecting higher education and research facilities across the United States.

for society.[37] As noted above, this is arguably all the more the case in contexts such as in the United Kingdom where much of the funding for higher education comes from taxpayers and, increasingly, from student tuition fees; academics have a moral obligation to share with and return to the public the work the public has paid us to do.[38] These authors recognize the irony and risk of exposing ourselves to accusations of hypocrisy: the work we describe in this article all took place in conjunction with at least one publicly funded university, and we all work and receive benefits from the higher education sector. This gives us all the more reason, though, to begin to effect the changes that we wish to see.

Concert venues in the United Kingdom do not usually have access to the Janet network and this limits networked music performance opportunities for musicians. However, this is beginning to change, and some cities provide exciting potential for local, community connectivity through LoLa. The Gala Theatre in Durham, England is connected to the Durham City Council network operated by the Council rather than sub-contracted to an internet service provider (ISP). This enables community leaders to direct resources in service of local people. Similarly, several Edinburgh concert venues such as the Festival Theatre and Queen's Hall are part of the Edinburgh City Council's Gigabit City network and could, in theory, connect to the Janet NREN using Edinburgh Napier University as a "bridge." The use of LoLa in the September 2019 BBC *Digital Planet* episode, for example, was made possible by using a BBC fiber connection to link the BBC Radio Theatre in London to the Janet connection four miles away in the Lighthouse, a BBC research and development facility. Where resources are available, we are already seeing the tremendous potential of deploying LoLa for social good.

It is also worth considering the social good provided or facilitated by the classical and jazz master classes and public concerts we have described, which are typical of the uses of LoLa to date (in addition to other one-off projects such as rehearsing and recording an original trio project to a click track).[39] The music on this latter occasion was hardly the most democratic or accessible—perhaps best described as "esoteric jazz fusion"—and has been disseminated only among fellow researchers. Although the U.K. government believes strongly in preservation and (ideally) consumption of more rarified music, these styles are not widely consumed in society and need propping up by substantial government funds. Indeed, the United Kingdom is the site of consistent

[37] For more on the social goals provided by institutions of higher education and research, see Dip Kapoor and Steven Jordan, "International Perspectives on Education, PAR, and Social Change," in *Education, Participatory Action Research, and Social Change: International Perspectives* (New York: Palgrave MacMillan, 2009), 1–13, https://doi.org/10.1057/9780230100640.

[38] For more discussion of the responsibilities of publicly funded institutions of higher education vis-à-vis the taxpayers who support them, see George Monbiot, "Scientific Publishing is a Rip-off. We Fund the Research – It Should be Free," *The Guardian*, September 13, 2018, https://www.theguardian.com/commentisfree/2018/sep/13/scientific-publishing-rip-off-taxpayers-fund-research.

[39] For more on rehearsing and recording original music using LoLa, see Zack Moir et al., "Real-Time, Remote, Interactive Recording Sessions: Music Production Without Boundaries," 194–208.

governmental "doublespeak" in terms of the value placed on the majority of music society produces and which government values for export and sales, and the kinds of music it promotes to the public for its perceived social good.[40]

Edinburgh Napier University is more accessible than some other universities (despite systemic and structural social issues that keep economic diversity in higher education at relatively low levels). Tuition is free at Edinburgh Napier University for students living in Scotland and European Union states as part of a policy initiative for which the government of Scotland has said, "We want every child, no matter their background, to have an equal chance of entering and succeeding in higher education."[41] At other institutions that have worked on LoLa projects, tuition fees along with social and financial barriers are substantially higher. At the Royal College of Music, for instance, fees are the equivalent of around $11,700 per year for full-time domestic students studying for an undergraduate degree.[42]

Music education and higher education are beset with apparent aporias, such as aspirations and claims regarding democracy, access, and equity, combined with and propelled by privileged academic practices like globe-trotting conference attendance and network-building.[43] The higher music education sector is increasingly accountable to an ideology of vocationalism, instrumentalism, and the transformation of all things into consumer goods.[44] While higher education has arguably always been premised on the elite assumptions and ideology of liberalism that emerged from Enlightenment thinking, the neoliberal paradigm has utterly transformed discourse in the sector so that it now reifies and rewards individual success, monetary gain and individual self-fulfillment over broader societal goals of collaboration and collective societal

[40] For more on conflicting government policy objectives regarding the value of cultural artifacts and activity, see Gareth D. Smith, "Doublespeak in Higher Music Education in England: Culture, Marketization and Democracy," in *The Routledge Handbook of the Sociology of Music Education*, ed. Ruth Wright, Geir Johansen, and Patrick Schmidt (New York: Routledge, forthcoming).

[41] "Universities," Scottish Government, accessed July 29, 2020, https://www.gov.scot/policies/universities/,

[42] "Royal College of Music Tuition Fees and Other Charges 2019/2020," Royal College of Music, accessed July 29, 2020, https://www.rcm.ac.uk/media/Tuition%20Fees%20and%20Other%20Charges%202019-20%20v2.pdf.

[43] On the topic of academic dispensations in music education, see Gareth D. Smith, "Neoliberalism and Symbolic Violence in Higher Music Education," in *Giving Voice to Democracy: Diversity and Social Justice in the Music Classroom*, ed. Lisa C. DeLorenzo (New York: Routledge, 2016), 65–67.

[44] For more on the effects of the turn toward an emphasis on vocational pathways in higher music education, see Tom Parkinson and Gareth D. Smith, "Towards an Epistemology of Authenticity in Higher Popular Music Education," *Action, Criticism, and Theory for Music Educatio*n 14, no. 1 (2015): 102; and
Mark Coté, Richard J. F. Day, and Greig De Peuter, "Academicus Affinitatus: Academic Dissent, Community Education, and Critical U," in *Utopian Pedagogy: Radical Experiments Against Neoliberal Globalization*, ed. Mark Coté, Richard J. F. Day, and Greig De Peuter (Toronto: University of Toronto Press, 2007), 334–52; For more on the increasing consumerization of society and its goods, and focus on monetary profit as a good in itself, see Hannah Arendt, *The Human Condition*, 2nd ed. (Chicago: University of Chicago Press, 1998), 162–163; Henry A. Giroux, *Neoliberalism's War on Higher Education* (Chicago: Haymarket Books, 2013), 13.

benefit.[45] This ideology persists despite aspirations and intentions expressed to the contrary in public-facing documentation; for instance, the University of Wisconsin System's adherence to the "Wisconsin Idea" that "education should influence people's lives beyond the boundaries of the classroom," or Boston University's stated goal that "research, scholarship, artistic creation, and professional practice should be conducted in the service of the wider community—local and international."[46] While faculty and staff worldwide work hard towards these and similar ideals every day, we do so in the face of some adversity. We hope that wider access may in time come about through commercial development and eventual mass production, but a public need must first be created; or to phrase it in another way, the public must be shown to see the value of the technology for them.

Conclusion

To date, technologies such as LoLa have been accessible only to the well-resourced, and they are unlikely to become more widely available until there is 1) greater awareness of their existence, 2) far wider access to fast networks and hardware with the capability to handle them, 3) greater understanding of their capabilities, and 4) a widely-enough held belief that it can provide significant value for a broad swath of the population (for instance by meeting one or more needs identified by arts or education communities). To achieve the potential social good brimming in technology such as LoLa, we need to see it prioritized in the funding of national and international arts initiatives and organizations, and in community and social strategies through public policy. It is conceivable—and more likely in some territories than others—that the State might play a role in helping bring more good to more people. As Cecilia Björk and Marja Heimonen note, for example, "in Finland and other Nordic countries, the state is expected to take an active role in creating conditions and circumstances for its citizens to live 'good', 'flourishing' lives."[47] Björk and

[45] For a critique of Enlightenment thinking, see Alain de Botton, *Religion for Atheists: A Non-believer's Guide to the Uses of Religion* (New York: Vintage Books, 2013), 82–83, 101; For more on the increased focus on individual success in higher music education as an end in itself, see Tom Parkinson and Gareth D. Smith, "Towards an Epistemology of Authenticity in Higher Popular Music Education," *Action, Criticism, and Theory for Music Education* 14, no. 1 (April 2015): 105; Stephanie Horsley, "Facing the Music: Pursuing Social Justice Through Music Education in a Neoliberal World," in *The Oxford Handbook of Social Justice in Music Education*, ed. Cathy Benedict, Patrick Schmidt, Gary Spruce, and Paul Woodford (New York: Oxford University Press, 2015), 71.

[46] On the "Wisconsin Idea," see "The Wisconsin Idea," University of Wisconsin-Madison, accessed July 29, 2020, https://www.wisc.edu/wisconsin-idea/#:~:text=One%20of%20the%20longest%20and,the%20boundaries%20of%20the%20classroom; for more on Boston University's social aims as a private research university, see "Mission Statement," Boston University, accessed July 29, 2020, https://www.bu.edu/about/mission-statement/.

[47] For more on the role of government and education systems in working towards flourishing and the "good life" for citizens, see Cecilia Björk and Marja Heimonen, "Music Schools and Human Flourishing: What Can National Education

Heimonen also note the examples of Bulgaria, Austria and Belgium as nations in which music education is construed and constructed for the enrichment of all in society.

Some ways in which the authors envision potential for those working with low-latency streaming technology to work towards achieving more social good are:

- Facilitating large-scale public participation in broadcast events such as the Armistice Day concert described in the essay, through increased involvement of institutions such as Edinburgh Napier University as "bridge" sites
- Welcoming the public into institutional settings by programming music that is more "of the people," including music made by community members and in styles that resonate with a greater cross-section of the public
- Advocating for strategic technology funding at local, regional, and national levels
- Publishing in open-access journals, demonstrating the potential and viability of low-latency networked music collaboration using LoLa
- Creating and utilizing specific funding and logistical initiatives for reaching remote and rural communities with low latency
- Creating and utilizing specific funding and logistical initiatives for reaching incarcerated populations, such as prioritizing prisons in local and regional strategic initiatives for low latency connectivity

Music education philosopher David J. Elliott argues that musicians should adopt an ethos and attitude of "well-doing" in and through music, by which he means "ethically-guided doing [which] is centrally related to personal and/or interpersonal projects and related social groups that children and young people engage in and with which they may decide to identify."[48] Gareth D. Smith and Marissa Silverman similarly affirm that music, taught ethically, can make major artistic, social, cultural, ethical, economic, and political differences in peoples' lives.[49] Music communities in both higher education and technology professions can draw on the work of these thinkers and others to envision ways in which LoLa and its applications might be considered "good enough." As Silverman notes, the ancient Greeks viewed music as a component of *mousike* and *paedia*, which

Policy Enable and Restrict?" in *The Future of Music Schools–European Perspectives*, ed. Michaela Hahn and Franz-Otto Hofecker (St. Pölten, Austria: Musikschulmanagement Niederösterreich, 2019), 37.

[48] David J. Elliott, "Eudaimonia and Well-doing: Implications for Music Education," in *Eudaimonia: Perspectives for Music Learning,* ed. Gareth Dylan Smith and Marissa Silverman (New York: Routledge, 2020), 109.

[49] For more on ethical music teaching and *eudaimonia*, see Gareth D. Smith and Marissa Silverman, "Eudaimonia: Flourishing through Music Learning," in *Eudaimonia: Perspectives for Music Learning*, ed. Gareth D. Smith and Marissa Silverman (New York: Routledge, 2020), 3–8.

position arts and learning as for the benefit of individuals and communities.[50] In this view, thriving fuses self and society, aspiring to ensure that what is good enough, does enough good.

The authors of this paper firmly believe in the potential of technologies that enable networked music collaboration to be deployed and applied for social good. We commit to doing what we can to ensure that they are—by working intra- and inter-disciplinarily at our respective institutions, with community organizations, and in applications for research funding. To quote Clint Randles, we believe in a "mantra of possibility" and that what is *good enough* musically and technologically can, and must, also *do enough good*.[51]

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[50] For more on conceptualizations of *eudaimonia* and human flourishing by philosophers in ancient Greece, see Marissa Silverman, "The Hull House: A Case Study for Eudaimonia in Music Learning," in *Eudaimonia: Perspectives for Music Learning,* ed. Gareth D. Smith and Marissa Silverman (New York: Routledge, 2020), 31.

[51] Clint Randles, *To Create: Imagining the Good Life Through Music* (Chicago: GIA Publications, 2020), 49.

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