The Playing Together, Apart Framework

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The Playing Together, Apart Framework: A framework for communication in Networked Music Performance

Abstract

The Playing Together, Apart Framework is a framework for understanding communication between musicians in Networked Music Performance (NMP). Previous research has largely focused on technical issues such as latency and synchronisation, and this framework aims to extend this research into further understanding of the experiences of, and the communication between, musicians in NMP, and the factors affecting this. The framework is based on duo musicians, working in informal NMP situations, playing acoustic instruments. The framework shows the audio and video communication paths, and the influences on both the transmission and reception elements of the communication chain in NMP. General issues in NMP, such as the rhythmic content of the music, the expertise and experience of the musicians when dividing attention, the use of video, and the socio-emotional and professional relationships between musicians are examined in further detail. This framework is proposed as a basis for further research into NMP, and for expansion and development by researchers.

Keywords

Networked music; communication; performance; ensemble; musicians' experience; social isolation.

Introduction

This paper presents a framework for understanding communication between musicians in Networked Music Performance (NMP) – the Playing Together, Apart Framework (PTAF). NMP has a wide definition, encompassing any music that is played or created using computer networks. This includes live coding methods used in algoraves (see e.g. Collins and McLean 2014), asynchronous methods - such as the remote recording that is used to make up virtual choirs - as well as musicians playing acoustic instruments and streaming audio to other musicians or to an audience. NMP transcends location, allowing access to live music (both as a participant and as an audience member) to anyone with an internet connection. NMP has traditionally been used for those isolated in some way, for example by geography, through niche musical interests, or those with difficulties travelling to music venues. The recent Covid-19 pandemic has brought this experience of isolation to people globally, and NMP has been a tool for individuals to access live or collaborative music in many forms. This has been particularly relevant for many community ensembles, where participation reduces social isolation and improves health and wellbeing (Dingle *et al.* 2013).

NMP has applications in performance, improvisation, collaborative composing, and music education, however there are technical challenges that need to be overcome when working in this way. Until recently, the study of NMP has been focused on the problems of latency and synchronisation (see e.g. Chafe and Gurevich 2004; Chafe, Cáceres and Gurevich 2010), as latency is inevitable when sending live audio over the internet, particularly using domestic internet connections. Latency is relatively easy

for musicians to overcome (using approaches outlined by Carôt and Werner (2009)), and more recent research has focused on issues affecting musicians, such as communication and presence (Delle Monache *et al.* 2018), for example.

Tsioutas et al. (2019) have developed a framework for understanding and defining quality of experience of NMP participants, encompassing four components: environment acoustic variables; musicians' personality traits and current emotional state; technical equipment; and musical context for performance. This framework was devised from the findings of a small quantitative study, involving four musicians. While there is some crossover between the framework presented by Tsioustas et al. and the PTAF, the framework presented here focuses on the impact of NMP methods on communication between musicians, rather than specifically the subjective experience of the musicians.

There is a need for further understanding of the experiences of musicians, including the communication between musicians and the factors affecting this for several reasons. As NMP is becoming more commonly used by musicians, especially in light of the Covid-19 pandemic, further understanding in this area will help those using NMP to understand the challenges they might face when using NMP technology, and how to approach these challenges with creative solutions. It may also help designers of NMP systems to focus on issues other than reducing latency (which will always be present in domestic situations with current broadband connections, and musicians can overcome latency in well-documented ways (see e.g. Carôt and Werner 2009)). In addition, the framework may help determine how a particular system might suit a particular musician, in terms of level of experience and style of working. It is hoped that the PTAF becomes a guide to researchers concerned with this important and timely research area.

The PTAF was developed from studies of duo musicians working in simulated synchronous NMP settings, playing acoustic instruments, and focuses on the communication between these musicians, and how the use of video and audio feeds impacts on the musicians as they play together. This work fills a gap in research, as it is based on the experiences of musicians when playing together remotely, rather than an evaluation of a particular piece of NMP software, for example. It is intended that the framework be used to further the study of NMP, particularly beyond issues of latency, as well as expanded into different NMP contexts, for example with larger ensembles.

Theoretical and empirical basis for development of the framework

The PTAF was developed through a synthesis of the findings from three studies: an exploratory study around musicians' experiences of NMP (Iorwerth and Knox 2015), a study specifically looking at the effects of physical separation during a recording session (Iorwerth and Knox 2019), and a study examining embodied communication in NMP (Iorwerth 2019). In addition, current work around communication, social and technical aspects of NMP, and approaches to NMP were used to inform the aims of these studies, and these are summarised below.

Communication in NMP

Communication between musicians is a wide research area, and encompasses methods for communication (verbal, non-verbal, and musical), as well the impacts of communication (on timing and synchronisation, for example). This area also covers

communication from a transmission and reception point of view, so includes musicians' sounds and movement, as well as their gaze and how they listen. The communication between musicians in NMP has been examined from the point of view of synchronisation (see e.g. Schuett 2002; Chafe et al. 2004; Darabi et al. 2008), but other factors (such as the ways musicians communicate in NMP, and the methods they use) have been largely overlooked. Shannon and Weaver's elements of a communication system (1949) is a useful starting point in the investigation of communication in NMP, to allow consideration of both the transmit and receive parts of the communication chain, and how musicians are affected in these two areas.

Playing music in an ensemble requires musicians to coordinate with others, and to do this, musicians must listen to, and look at one another, and make dynamic adjustments to their own playing (Dobson & Gaunt 2015). Coordination does not require visual contact between musicians, but visual contact can help musicians to synchronise when co-performers' intentions are difficult to predict (Kawase 2014), and expression is greater when visual contact is available (Keller & Appel 2010). This research on musical communication has an impact on the potential use of video in NMP. While interruption of visual contact between musicians in NMP may not lead to problems synchronising in many musical situations, this previous research suggests that visual contact may be useful when the intentions of a fellow musician are unpredictable, for example if the tempo of the piece performed is not constant, or during improvisation.

Within the group context musicians communicate with each other and an audience, through a combination of verbal and non-verbal methods. Non-verbal methods include eye contact and body language, as well as musical communication through variations in way the music is played (Goodman 2002). Non-verbal communication increases between musicians as auditory feedback decreases (Goebl & Palmer 2009). While musicians playing in different genres have differing performance traditions, it is thought that the methods of communication used are common across genres (Seddon & Biasutti 2009). Commonalities in the communication between musicians in different genres are an advantage when studying NMP, as it suggests that musicians across all genres may be affected similarly by the challenges of NMP. The methods used by musicians in NMP will depend on the aural and visual connections available to them, however it is likely that individuals will need to modify their usual communication methods to fit the particular NMP tools they are using.

Despite the importance given to non-verbal communication and visual connection in music communication research, there are several gaps in the current research. The first is relating to musicians' gaze: there is minimal literature on musicians' visual attention when they are playing, and how much they attend to one another while playing, for example. One relevant study around a string quartet's gazing behaviour (Glowinski et al. 2015) measured gaze in only the horizontal plane which prevents the findings from being useful in this context. Secondly, the role of video in NMP was unclear in previous research: some studies have suggested that musicians only minimally use the video stream, based on musicians' self-report (Cáceres & Hamilton 2008; Mills 2011).

The use of video, therefore, was included in the studies leading up to the framework to establish how and when musicians use a video link – from both an objective and subjective point of view – and to examine whether the benefits of video outweighed the bandwidth requirements. The findings relating to the use of video (and therefore

visual communication) from the studies (Iorwerth and Knox 2015, 2019; Iorwerth 2019) informing the PTAF were:

- Subjective and objective use of video did not match;
- The video link was used more in discussion than when playing, and was beneficial for social interaction, rather than musical coordination;
- Musicians looked at each other more in a NMP situation than when collocated, but individual differences were large. This was perhaps to compensate for additional communicative challenges in NMP; and
- Musicians rarely looked at each other in NMP when using notation.

In addition, musicians' gestures are of direct relevance to NMP, as they provide the channel for non-verbal communication, which may be affected by the use of a video link. While gesture is well researched in the context of live performance, both in terms of communication to an audience (e.g. Kurosawa & Davidson 2005) and between co-performers (e.g. King & Ginsborg 2011), in the context of NMP this was an area that required further investigation. The summary of findings relating to musicians' gesture in the studies (Iorwerth and Knox 2015, 2019; Iorwerth 2019) informing the framework are as follows:

- Some musicians deliberately looked at their co-performer to gain performance cues;
- Some musicians made deliberate communicative gestures;
- It is likely that musicians divided their visual attention between a video monitor and their surroundings; and
- Some performance gestures were lost in NMP due to the camera view.

In addition to the communication modes discussed above, listening is relevant to NMP: musicians must listen to themselves as well as other musicians, and the overall blend of the instruments in an ensemble. This listening can be disrupted by various factors including rhythmic complexity, poor balance, and uncomfortable surroundings (Keller 2001), all potential factors in NMP. For these reasons, listening was included in the PTAF. In the studies (Iorwerth and Knox 2015, 2019) informing the framework, it was found that:

- Loudspeakers were preferable to headphones for monitoring;
- Dynamic matching between musicians was difficult;
- Musicians changed the way they listened when they encountered difficulties in NMP; and
- The removal of video focused the musicians' attention on listening, which may be beneficial.

Social aspects of NMP

Playing music in an ensemble is a social activity. Musicians working together regularly build up socio-emotional, musical, and sometimes professional relationships (Blank & Davidson 2007). These relationships lead to successful communication, which facilitates musical communication and leads to effective conflict resolution (Murnighan & Conlon 1991). Skills and knowledge relating to co-performers are built

up over time and lead to successful performances. These relationships build up not just through time spent performing together, but also time spent before and after performances, which may be considerable in the case of touring musicians. The social aspects of NMP are different, with some benefits and drawbacks: NMP has the potential to allow geographically dispersed musicians to play together, as well as form online communities of practice, however time before and after performances to build relationships is likely to be limited. Due to these differences, it has been suggested that in NMP musicians may not want to aim to reproduce a typical face-to-face scenario, rather they might embrace the unique features of NMP to create music based on distant relationships and the unknown (Schroeder & Rebelo 2009). While some musicians using NMP in an informal way may see it as a unique space for experimentation, many musicians will see it as nothing more than a tool to allow collaboration across distances.

In the studies contributing to this framework (Iorwerth and Knox 2015, 2019), musicians' socio-emotional, musical, and (where relevant) professional relationships were an important factor in the success of their NMP sessions, from the musicians' experience point of view, and from the point of view of the music produced. The findings from these studies suggested that musicians took into account the following in NMP, as they are particularly heightened compared to collocated performances:

- Paying particular attention to trusting, respecting, and supporting co-performers;
- Allowing dynamic musical leadership;
- Having and maintaining strong socio-emotional relationships;
- Considering conflict resolution; and
- Minimising isolation.

Technical aspects of NMP

Latency affects all musicians due to the physical distances between musicians, the delays between a note being initiated and an instrument producing the sound, and performance errors (Bartlette *et al.* 2006). Conductors help to prevent problems with latency, but even without a conductor musicians easily adapt to delays (Lago & Kon 2004). In NMP, the latency due to acoustics is replaced with that caused by delays in the equipment used, and is compounded by packet loss and jitter. Latency is thought to be the biggest issue facing musicians in a NMP setting and has received the most attention by researchers. Various attempts have been made to quantify the largest latency musicians can cope with in a NMP setting (see e.g. Schuett 2002; Chafe et al. 2004; Darabi et al. 2008), however, the style of music played and the approach towards NMP has a large effect. 25 ms is considered the threshold for synchronous performance (Carôt et al. 2006), however performances have been successful with higher latencies (Bartlette *et al.* 2006). The debate on specific latency thresholds has abated recently, suggesting that there is no one specific threshold; rather the context (including musicians, instruments, and styles played) has a large role to play.

Contributing to the debate on latency tolerances of musicians was not an aim of the research contributing to this framework; however the EPT of 25 ms has been used as a useful guide for acceptable latencies when NMP was simulated in the studies. While researchers have been very thorough in their investigation of latency and synchronisation in NMP, the subjective experience of the musicians has received less attention, which has been addressed in these studies. This includes how the musicians

are affected when they play with latency, and how it affects both practical aspects and thoughts about their own playing, and how they react to others. In addition, other technical aspects of NMP, including the role of audio quality and monitoring arrangements on musicians, were included.

The findings relating to technical issues from the studies (Iorwerth and Knox 2015, 2019) informing the framework are as follows:

- Technological issues caused fewer problems than expected;
- Musicians adapted by drawing on previous experiences, and those of co-performers; and
- Musicians dealt with latency using well-documented leadership methods.

Approaches to NMP by musicians

Musicians have different approaches to working with NMP, including working as if they are in a traditional collocated situation (which works at low latencies), having a leading and following musician in order to keep synchronisation, or treating the latency as a feature of the network 'space' and including it in the music (Carôt & Werner 2009). This can have the effect of providing network reverberation or echoes, which can become a feature of the music. There have been technological solutions to minimise latency, such as transmitting control signals instead of audio (Weinberg et al. 2002; Blaine & Fels 2003b; Gurevich 2006), but these require specialist software at both ends of the collaboration. Asynchronous NMP is not affected by latency; however it also prevents the spontaneous creativity allowed by real-time music making.

Achieving coherent performances was a theme that emerged in the studies (Iorwerth and Knox 2015, 2019) informing the PTAF, with the following findings:

- The definition of a coherent performance in NMP depends on the perspective of the listener/performer;
- Coordination of timing was difficult in some conditions, especially at entries;
- If typical timing cues were lost, the musicians adapted and used others;
- Tuning was affected due to monitoring arrangements; and
- Blending and dynamics were also affected by monitoring arrangements.

In most NMP settings that have public performance as their aim, the musical content has either been free improvisation (e.g. Mills et al. 2016) or music composed specifically for the setting, such as in the Online Orchestra project (Rofe & Geelhoed 2017). In more lab-based work, a wider range of music has been used, including simple jazz-based tunes and classical chamber music (e.g. Bartlette *et al.* 2006). In a public performance context, the organisers aim for music that is safe for musicians to perform, i.e. music that will work well in the NMP context. Free improvisation is an example of this, with no set expectation of the audience, and with musical content that can evolve to the precise technical issues in the moment. Composing music specifically for a NMP set-up is also safe for musicians to perform, but inflexible: a particular set of instruments in particular places may be needed to recreate the piece. Descriptions of the musical parameters used in this type of composition (see e.g. Rofe & Geelhoed 2017) also suggest that the resulting compositions may be somewhat musically limiting. In addition, many domestic participants in NMP will aim to play

music within their current performance repertoire, so free improvisation and especially composed pieces may not suit them. Given this, the studies (Iorwerth and Knox 2015, 2019) focused on the repertoire that performers choose to play using NMP, how this suited the technical set-up, and whether musicians modified their playing to suit NMP. The findings were as follows:

- Both the broad rhythmic overview and finer rhythmic details were important when considering musical content for the NMP settings;
- Most styles of music played in the studies were suitable for the NMP settings;
- Musicians took fewer risks in the NMP settings; and
- As a result of reduced risk-taking, creativity was reduced.

Given the unavoidable latency introduced when transmitting audio over long distances on the internet, the approach of attempting to recreate traditional performance settings seems somewhat futile. While systems such as LOLA (Conservatorio di musica G. Tartini 2015) manage to reduce latency to manageable levels, this is at great cost in terms of equipment needed, bandwidth requirement, and technical expertise. The PTAF is based around NMP as it might be used by a typical performing musician for rehearsal, who is unlikely to have access to high-speed networks and dedicated NMP equipment; therefore it is likely that some adaptation by the musicians will take place to successfully work with the technology. These informal applications of NMP have been largely ignored in research, in favour of high-speed, low latency systems, or large-scale public performances.

The Playing Together, Apart Framework

Throughout this research, communication between musicians has been a major theme that has pervaded all aspects of the musicians' experience, from their social isolation, synchronisation, performance gestures, gaze, and listening, to the rhythmic content of the music and their use of video. The communication required for musicians to perform together is no different than that of musicians playing together in a typical, collocated ensemble situation, however the transmission of communicative sounds and gestures is interrupted by the use of an audio and video link. A framework is proposed that describes the factors affecting musicians in informal duo NMP, and how each factor affects individual parts of the communication chain (Figure 1). While the framework is based on the informal duo context of NMP, it can also form the basis for further development and expansion to encompass other NMP settings, and for future exploration of the issues musicians face in NMP.

Communication in NMP

The PTAF shows the audio and video communication paths (based on Shannon and Weaver's elements of a communication system (1949)), and the influences on each part of the communication chain in NMP. Each musician both transmits and receives information simultaneously, and in the diagram the communication chain is pictured as a continuous loop with the receiving affecting the transmission, iteratively.

There are three parts to the framework: the two musicians at each end, with their actions mirroring one another, and the NMP system itself in between the two musicians. There are influences on the two individuals, including their own experience and confidence in playing, which in turn affect what the musicians transmit through their body movements and the music played. These are affected by

the instrument played, and conventions of the genre, etc., and the rhythmic content of the music will affect how successfully it is transmitted through the NMP communication chain. The body movements and music played is transmitted to the co-performer, through the audio and/or video connection.

The impact of the audio/video loop is affected by technical issues such as latency, jitter, and compression artefacts, as well as the reduced field of view caused by the use of a video camera and monitor. The technical impacts on the audio chain in NMP have been discussed extensively in previous literature (in particular the impact on musicians' synchronisation), while the impact of the use of video has been a focus in the studies feeding into the framework (Iorwerth and Knox 2015, 2019; Iorwerth 2019).

How well these degraded signals are received is affected by the receiving musician's knowledge of the other player, for example, as well as how well they are able to listen for musical aspects such as tuning and dynamics. Receiving musicians must then process this information and predict the consequences of their actions simultaneously (Maes *et al.* 2014). They react and play their parts, while making their own body movements, and the loop continues.

While some aspects of this chain are related to individual idiosyncrasies when playing, such as individual playing style and confidence, there are some more general effects, such as: the rhythmic content of the music; the expertise and experience of the musicians in terms of their ability to divide their attention; the use of video; and the socio-emotional and professional relationships between musicians, which will now be examined in more detail. Each of these aspects are on a continuum and will affect different musicians to different extents.

The PTAF is particularly useful in demonstrating the relationship between the different factors affecting the musicians in the informal duo NMP contexts in the studies feeding into the framework, as well as in identifying whether there is an impact on the audio or video part of the communication chain. In addition it may be useful in the future for predicting the impact of the use of NMP on any particular musician, based upon their particular skills, and the music they are playing. This would, however, require further testing with a larger range of musicians, as currently the model is based purely upon the musicians and NMP set-ups used in these studies.

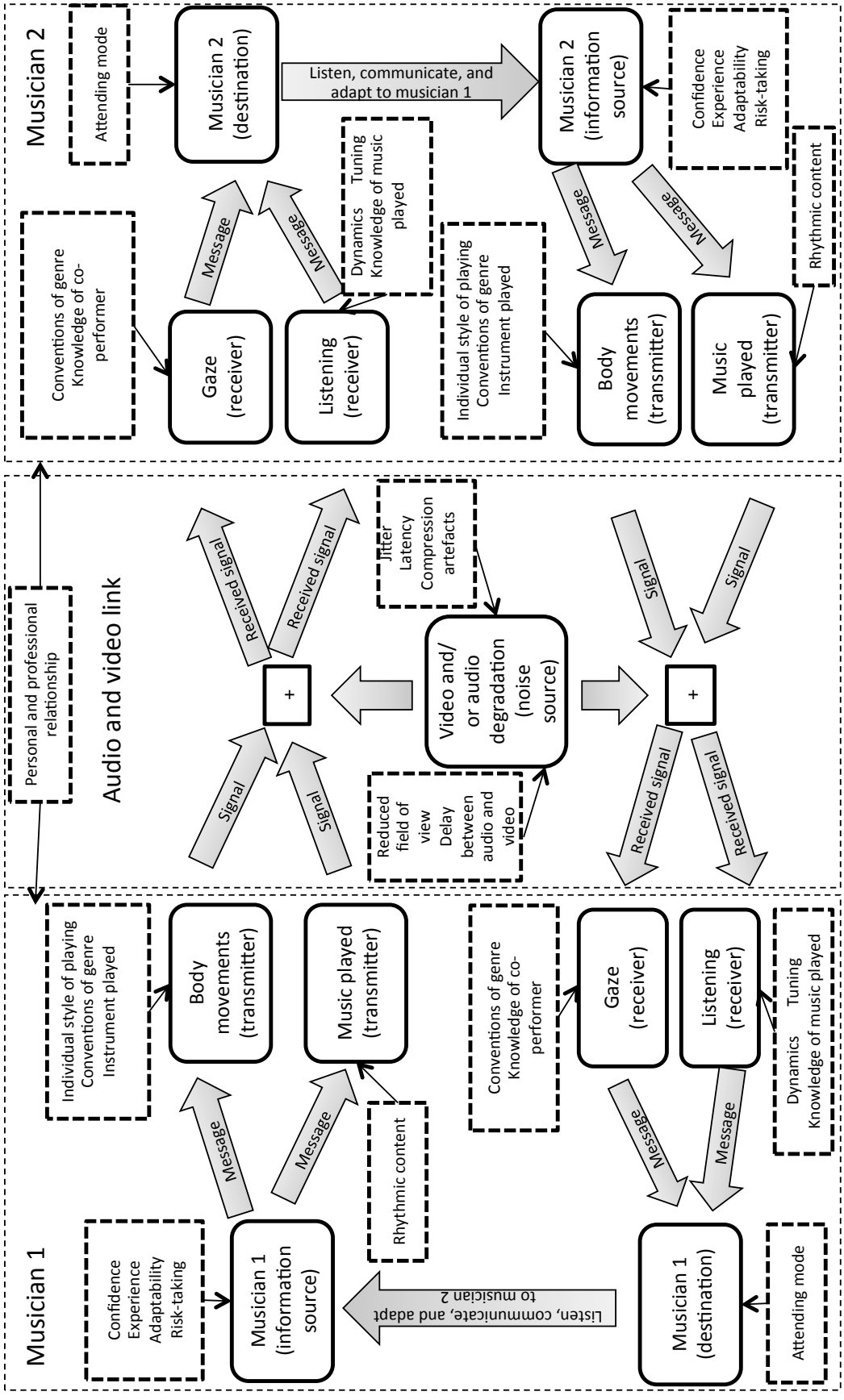

Figure 1: Playing Together, Apart Framework (PTAF)

Rhythmic content of the music

As highlighted, the choice of musical content, and particularly the rhythmic content, affected the success of the simulated NMP and the ease with which musicians can play in these sessions. Figure 2 shows the impact of particular rhythmic features of the music on these NMP sessions. Steady, predictably rhythmic music had the least impact on musicians in NMP situations, as well-documented methods were used to mitigate latency and other communicative difficulties (see e.g. Renaud, Carôt and Rebelo 2007; Carôt and Werner 2009; Chafe 2011). When the music contained minor tempo changes that required non-verbal communication between musicians (including eye contact or listening for breath, for example), difficulties sometimes occurred with timing and synchronisation, however these were usually minor and quickly resolved. At the furthest end of the rhythmic spectrum is fully improvised music, with unpredictable tempo changes and rhythmic content. Although this was not included in the studies, it is likely to have a major impact on the ability of musicians to coordinate their timing intentions. It is possible, however, that music with these characteristics is very well-suited to NMP: the unique features of the network 'acoustic' can be embraced and used as part of the creative process, with the caveat that the musicians expect a different experience to playing in a collocated situation.

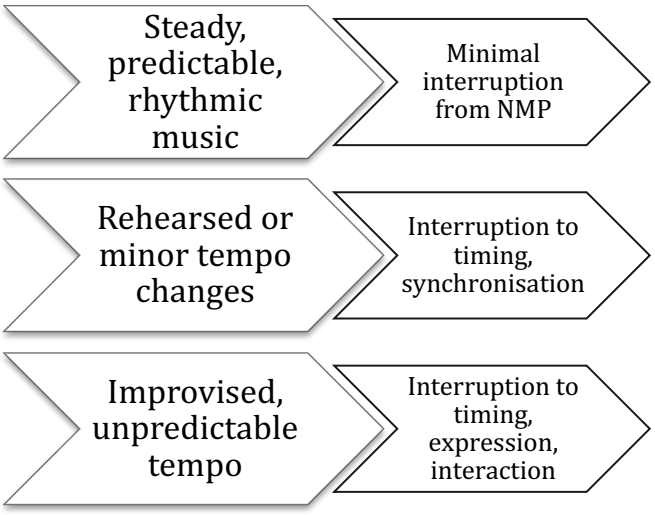

Figure 2: Impact of musical content on NMP

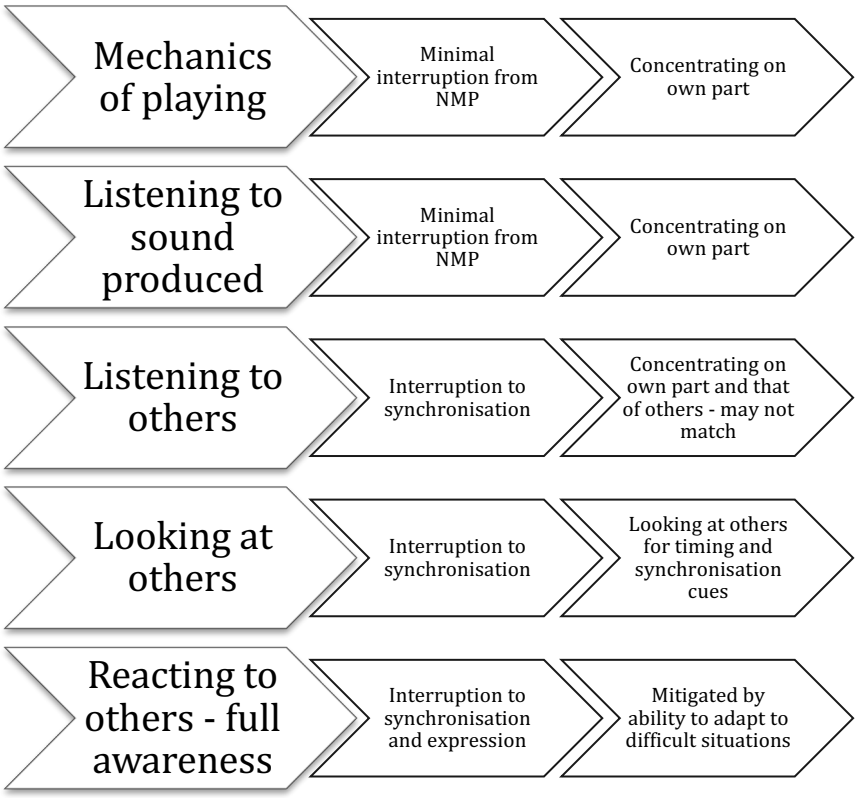

Figure 3: Impact on musicians: divided attention

Divided attention

The ability of the musicians to divide their attention between their own playing, listening and looking at those around them, and reacting to others was also a factor in the success of the NMP sessions in the studies outlined above. These skills are likely to be gained as expertise as a performer increases, and as the listening skills of musicians develop, including shifting attention to different parts of the music (Madsen and Geringer 2000), from broad to more specific. Figure 3 shows the likely relationship between musicians' ability to divide their attention and react to others: their musical 'radar' (Dobson and Gaunt 2015). Inexperienced musicians are likely to focus on the mechanics of their playing, and pay little attention to what is going on around them – in this case they are not likely to be affected by the use of NMP technology, as they concentrate on their own part. As musicians develop experience they become more aware of their surroundings by listening to themselves, then others, and then looking at others and reacting to others' actions. As this awareness increases, potentially so will the impact of the NMP technology. Synchronisation cues, for example, may get lost when non-verbal communication becomes difficult. At the far end of this spectrum, however, it is likely that something different will happen: when musicians are extremely experienced they are able to adapt to difficult situations (including acoustics, and working with many different players). This means that the impact may be less for highly experienced players than for intermediate musicians.

Impact of video

The provision of video in NMP is probably the most contentious issue for musicians using NMP, due to the conflict between the perceived need and the actual need. As demonstrated in these studies, video was not necessary for successful performances, and in many cases musicians have reported that they do not use the video link often. This has been disputed by objective measurement of the use of video, where musicians actually look at each other more when they have a video link than when they are in a room together (Iorwerth 2019). Despite this discrepancy, it is clear that a video link was not a requirement for successful performances. Social connection and communication, however, may be improved when one is provided. Whether or not a video link is used, in the context of these studies, it was clear that the link did not need to be of high quality to have a benefit.

The choice of whether to include video or not comes down to available bandwidth: given the aural nature of music, degradation in the audio signal beyond a certain point should be avoided. If this is not an issue, however, then video may be included. The experience of the musician may be different with an audio-only link, where listening becomes more concentrated, and this has the potential to benefit the musical collaboration (see Figure 4). Alternatively, with a video link it may be tempting to try to recreate a typical collocated situation, which could ultimately lead to frustration. Communication may be better, however, especially in terms of social interactions. In terms of the success of musical collaborations, the use of video did not produce better outcomes, only different experiences for the musicians (Iorwerth and Knox 2015).

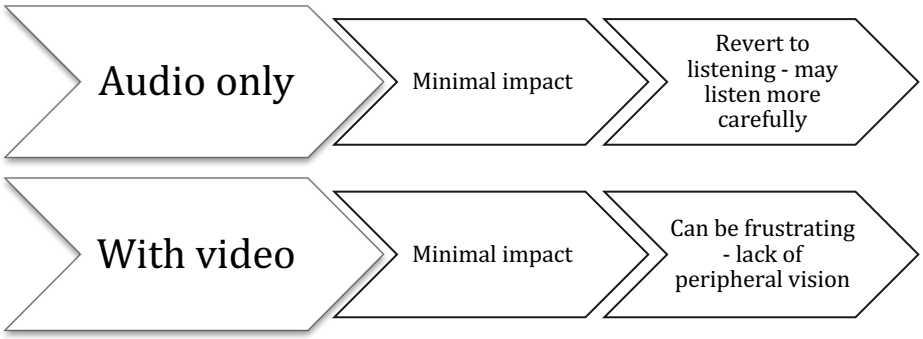

Figure 4: Impact of video

Relationships between musicians

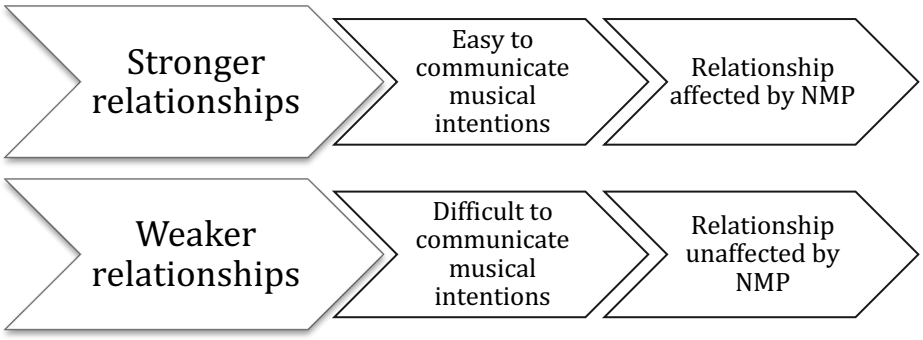

Figure 5: Impact of relationships

While the socio-emotional and professional relationships did not have a direct impact on any one part of the communication chain in NMP, in the studies highlighted, the impact on the musical interactions have been two-way: good relationships helped the musicians to play well together in NMP, and use of NMP technology has the potential to impact on these relationships (see Figure 5). It is likely, therefore, that musicians with no pre-existing relationship may find NMP particularly difficult when attempting to communicate musical intentions, while those with strong existing relationships will be less affected (due to the musicians' knowledge of their co-performers' individual style of playing). In contrast, those with no pre-existing relationship will be less affected by the impacts of the technology (i.e. they have less to lose), while those with strong existing relationships are likely to be more affected. It is likely that the more the musicians use any available video link, particularly when not playing, the less negative impact there will be on the musicians' relationships.

Conclusion

NMP allows musicians to work together across distances, which is particularly important for those who are isolated from others – something that has recently been experienced worldwide during the Covid-19 pandemic. This has highlighted the importance of ensemble music activity on musicians' health and wellbeing, and NMP allows access to this even when musicians cannot be physically present with one another.

Previous work on NMP has principally focused on the technical aspects of playing together with latency, largely ignoring the important aspect of communication between musicians and the impact of the use of NMP technology on the musicians' experience. This paper has presented a nascent framework for understanding musicians' communication in NMP, and this is proposed as a basis for further research, expansion, and development for researchers.

The PTAF has several potential uses for researchers. It could be used as a basis for evaluation of current or new NMP systems, to examine specifically how the features of a particular system might impact on musicians' communication. It may be used by software developers when considering the features they wish to include in an NMP system, and how these might impact on musicians.

It may also be used as a framework for further research into musicians' experiences in NMP. Each area of the framework (for example, the particular impact of individual

style of playing on a musicians' body movements, or the knowledge of the music played on listening) would benefit from further research, as this was beyond the scope of the original research project. It is hoped that this framework will help to move research into NMP beyond the technical issues for performers, and further into the subjective experience of musicians in NMP, in many different contexts.

As discussed previously, the framework was developed as a result of the experiences of the particular musicians in the particular NMP set-ups in the studies highlighted, and therefore has limitations. In particular, the studies involved duo musicians, the majority of whom were playing informally, in rehearsal situations. While it may be useful for other forms of NMP, testing and/or modification for larger ensembles and different NMP contexts would be welcome.

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