That Syncing Feeling: Networked Strategies for Enabling Ensemble Creativity in iPad Musicians

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Abstract
The group experience of synchronisation is a key aspect of ensemble musical performance. This paper presents a number of strategies for syncing performance information across networked iPad-instruments to enable creativity among an ensemble of improvising musicians.

Acoustic instrumentalists sync without mechanical intervention. Electronic instruments frequently synchronise rhythm using MIDI or OSC connections. In contrast, our system syncs other aspects of performance, such as tonality, instrument functions, and gesture classifications, to support and enhance improvised performance.

Over a number of performances with an iPad and percussion group, *Ensemble Metatone*, various syncing scenarios have been explored that support, extend, and disrupt ensemble creativity.

Keywords
mobile music, ensemble performance, networked performance, group-mind

Figure 1. *Ensemble Metatone* performing *MetaLonsdale* for networked iPad quartet in Canberra, October 2013.

Introduction
Working with software based musical instruments presents unique opportunities for enhancing ensemble performance by sharing information among the networked instruments. In a series of iPad apps designed for *Ensemble Metatone*, a group brought together to explore iPad and percussion performance through free improvisation, we developed a number of strategies for syncing information across the ensemble of devices to assist the performers to create coherent musical structures and to encourage them to explore a wider range of sonic ideas. While touch-screen musical instruments are becoming commonplace in music education and professional performance, software design for such instruments has yet to take group performance into account to truly support and extend musicians' existing creative practices.

The apps presented in this paper have been designed specifically for performing free-improvised music by the percussionists in *Ensemble Metatone*. Free-improvised music has been defined by Stenström as performance "without any restrictions regarding style or genre and without having predetermined what is to be played" [16]. Mazzola [12] emphasises that free improvisors "have to negotiate (while playing) with their fellow players every single item they bring into play. . . they generate the music as if partaking in a dynamic and sophisticated game." This is a style of performance where communication between performers affects not just the success of the performance, but the nature of the musical work itself. Borgo reports the free-improvising musician's experience of "group mind" [2], where musicians can react effortlessly to each other due to a certain level of experience and trust with the group's performances. We have found that syncing aspects of performance in our apps can enable aspects of a group mind experience.

In designing our apps we have followed a "percussionist-led" approach. The artistic practice of percussion is one defined more by interaction - percussionists perform by "striking, scraping, brushing, rubbing, whacking, or crashing any... available object" [15] - than by particular instruments. For percussionists, free improvisation is often a process of gestural exploration, of discovering new sounds from instruments and found objects and responding to an ensemble. We designed our apps to respond

to a vocabulary of touch gestures identified from a set of free-improvisations in rehearsal sessions [11]. Our apps map these gestures to a range of sound material and musical textures. In this way, we maintain a focus on direct manipulation of sounds rather than other paradigms of musical creation such as controlling algorithmic processes or sequencing events [5].

In the following sections we describe the design of three apps developed for *Ensemble Metatone*, MetaLonsdale, BirdsNest, and Singing Bowls. In each case, we used network connections between an ensemble of iPads using these apps to sync musical information during the performance. These apps were used by *Ensemble Metatone* over a number of experimental rehearsals and performances where the musicians were interviewed about the group performance experience. We are able to conclude from this feedback that our syncing strategies are successful in stimulating cohesive and adventurous performances, but that the automatic changes in user interface can present musical challenges to the performers. While these challenges can disrupt musical flow, they may be one of a range of interactions that form part of the group mind experience.

Syncing Strategies in Computer Music

In commercial music software there are existing and well-worn standards for sending information between instruments or between performers. These standards generally focus on syncing rhythmic information between multiple sources of sequenced sounds in an ensemble or individual performance. The MIDI standard [13], originally designed as a digital replacement for voltage controlled hardware synthesisers, has been used extensively in software instruments. Its specification includes two different messages for synchronising performances, *MIDI Time Code* which communicates a position in time since the start of a performance, and *MIDI Timing Clock*, which sends 24 messages per crotchet beat and so is dependent on the tempo of a song. MIDI Timing Clock messages are frequently used to synchronise several electronic instruments, functionality referred to as "MIDI Sync", for example, a drum machine and a sequencer, either using hardware or virtual software MIDI connections. A networked version of MIDI exists [9] and is often available in touch-screen music apps.

Using multiple mobile devices at once has become a common practice both in ensemble situations and for individual performers who may want to make music using, for example, both a smartphone and tablet. Korg's Wireless Sync-Start Technology [8] (WIST) software framework shares tempo, start and stop commands between iOS devices over Bluetooth in much the same way as "MIDI Sync" while removing the necessity for physical MIDI cables or a WiFi network. Since the WIST framework is freely available under a New BSD License, it has been incorporated into many musical iOS apps.

Open Sound Control [6] (OSC) is a general format for sending musical control signals over a network. Unlike MIDI, OSC messages have no set meanings and functionality must be defined by the developer and user. While OSC is used in some commercial software it is mostly used by research-situated artistic ensembles for communication between performers and their instruments. For example, cross-artform group, *Last Man to Die* used OSC to connect MIDI instruments, a heartbeat sensor and a tangible table-top interface to computer audio and visuals [10]. The GRENDL [1] system loads and starts a repertoire of computer music compositions among an orchestra of laptops, while Kapur et al's *Machine Orchestra* [7] use OSC to transmit a variety of control data between human and robotic performers.

All of these standards and systems introduce a certain amount of computer mediation of musical performance to extend human performers' creativity. The computer can assume the responsibility of keeping time, as in WIST-enabled apps, distribute control messages to multiple musical instruments, as in the *Machine Orchestra*, or transform gestures between multiple artforms in *Last Man to Die*.

Our goal with the Metatone apps was to create instruments for use by professional percussionists, and therefore we felt that we shouldn't try to take responsibility for rhythm or direct control of sound away from the performers. We were also concious of disturbing the relationship between the performers, their instruments, and their audience with additional visuals, or sound sources apart from the performers themselves. For our apps, we developed ways to sync more abstract musical information between the instruments the performers were using. Extending the characterisation of percussive improvisation as gestural exploration of instruments, we propose that if the instruments are dynamic interfaces, with properties and functionality that change throughout a performance, this could enhance rather than disturb the performer's exploration. To help an ensemble to reach a state of "group mind", we can create instruments that change in sync with each other, affording the performers opportunities to explore new sounds and musical structures together. In this way, we support the ensemble in creating coherent and compelling improvised music without removing their agency for controlling rhythm and pitch, the core aspects of music.

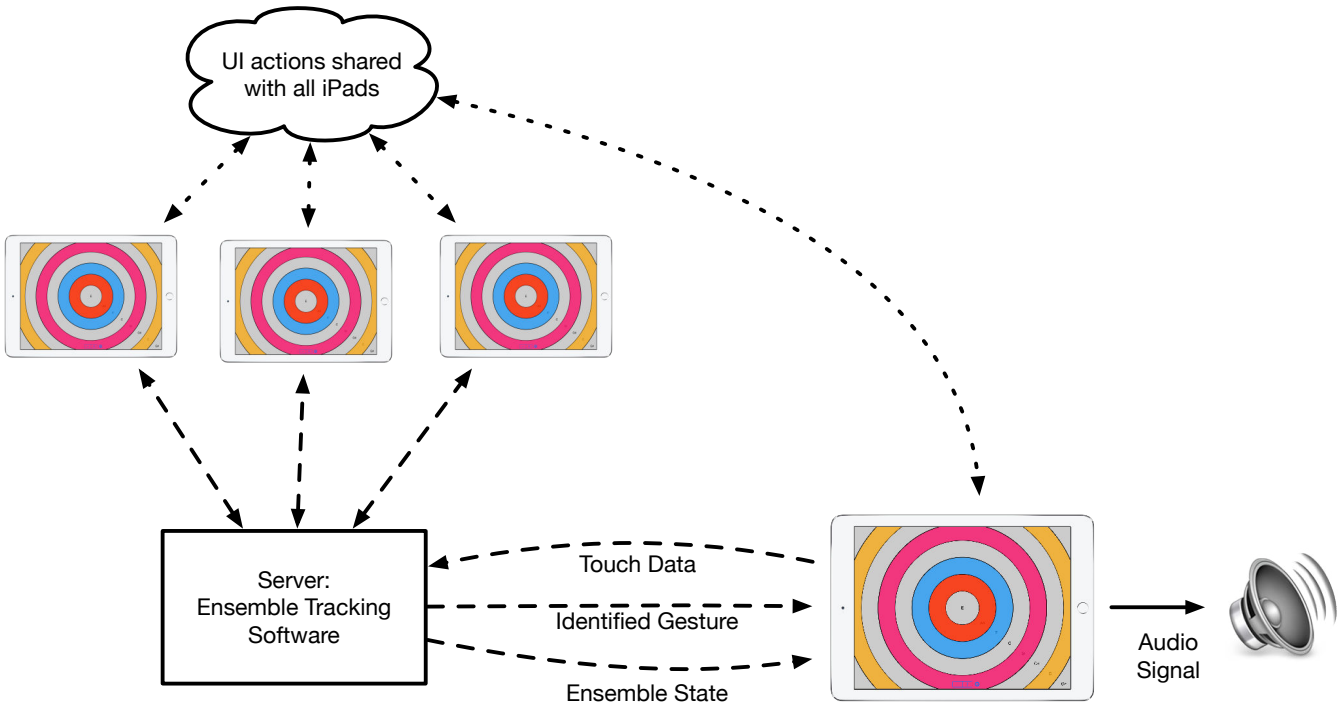

Figure 2. The network architecture of a metatone performance with a detailed view of one iPad. Each iPad connects to each other automatically as well as to the ensemble-tracking server software. The performers' interaction with UI elements (buttons and switches) in the apps are shared between the iPads. All touch interactions are logged and classified into gestures by the server which returns individual gesture and ensemble state information throughout the performance. Each iPad creates its own sound which is projected from a loudspeaker via the iPad's headphone jack.

Metatone Apps

Ensemble Metatone was founded in April 2013 to study the performance of free-improvised music with specially designed iPad apps as well as physical percussion instruments in Canberra, Australia. The members of the group (including one of this paper's authors) are trained percussionists and improvisors. Much like a percussion ensemble, the group performs with a large setup of instruments on stage so that each performer can access a number of sounds including one iPad for each player. One loudspeaker is used for each performer and is placed directly behind their setup so that the acoustic and electronic sounds from each musician emanate from the same location on stage. The group also performs iPad-only works without any other instruments as in Figure 1. After an initial series of studio rehearsals with a non-networked app, we began performances with dynamic apps that sync information about the state of the other performers and update their interfaces in response.

Our Metatone apps share information over a WiFi network using OSC messages sent using the UDP protocol. Each app advertises itself on the network using Bonjour (zero-configuration) networking and automatically connects to other apps that it finds. To facilitate using the same networking code in all of our apps, the Objective-C OSC library (F53OSC) and network management code was gathered together in one open source project, MetatoneOSC[1].

We also developed MetatoneClassifier, a server-based, Python application that logs the performers' touch and interface interactions as well as any information shared between the apps. These detailed recordings of performances can be used for research and also, as discussed below, for tracking the group performance in real-time and making calculated interventions into the apps' functionality.

All of the Metatone apps use a percussion-inspired interaction scheme that allows the performers to explore field recordings, percussion samples and pure-synthesised sounds through taps and swipes in a performance area that takes up the majority of the screen. Taps produce a short sound with a natural decay (similar to percussion instruments) while swipes produce a continuous sound where volume is controlled continuously by the velocity of the swipe. Pitched sounds are arranged radially with the lowest pitch accessible by tapping the centre of the iPad screen and the highest at the corners. The apps use the libpd library for audio synthesis, this library allows the synthesis part of the application to be developed in the Pure Data computer music environment while the rest of the application is developed in Objective-C.

[1] `http://github.com/cpmpercussion/MetatoneOSC`

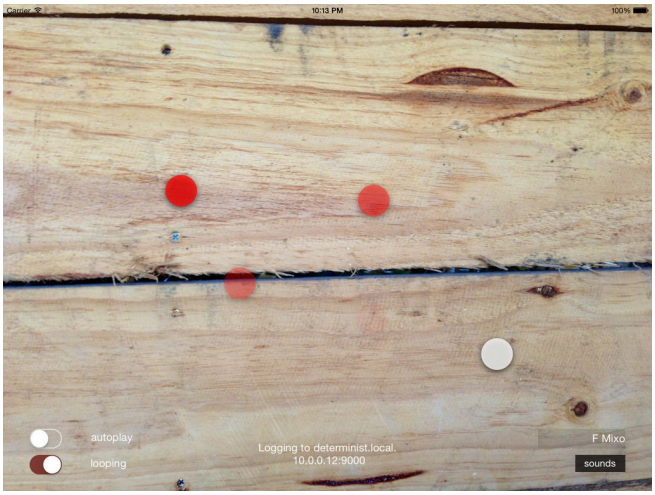

Figure 3. Screenshot of the MetaLonsdale app. The white circle denotes the performer's touch while the red circles are looped notes. The looping and autoplay functions are controlled by switches on the lower left, while the sound and tonality can be shuffled with the 'sounds' button on the lower right.

Figure 4. The BirdsNest app features field-recordings and images from a forest in Northern Sweden. Performers create a sonic journey through this forest by exploring the available sound material from the forest floor to a bird's eye vantage point.

MetaLonsdale

MetaLonsdale (seen in figure 3) was the first networked app developed for the group. Originally produced for a concert in Canberra's Lonsdale St Traders, a collection of galleries, cafés and pop-up shops, the app features field recordings from a busy Saturday at the venue and pitched percussion samples. The app has four UI elements positioned at the bottom corners of the screen to adjust the functionality, sounds, and to view the currently available musical scale. Two switches control a "looping" function, that repeats tapped notes, and an "autoplay" feature that plays soft field recordings continuously. While the app has a library of sounds, only a few are available to the player, a "sounds" button shuffles the accessible sounds from the library.

While earlier prototype apps had allowed access to chromatic pitches, a design goal of MetaLonsdale was to use a collection of scales to produce a sense of harmonic progression in the performance. A cycle of three scales were chosen: F mixolydian, F# lydian, and C lydian #5. Tapping the "sounds" button had a 25% chance of progressing to the next scale in this cycle. Although the performers cannot see precisely what pitch they play, the name of the currently available scale can be displayed for performances where the app is used together with other physical percussion instruments.

For the harmonic progression built into MetaLonsdale to come across to the audience, it was necessary for all the iPads in the ensemble to have the same scale. Whenever one player triggers a change in tonality by tapping the "sounds" button, this is communicated to the whole ensemble. The effect from the performers' and audience's point of view is of a series of synchronous transitions between harmonic material.

The other UI controls of MetaLonsdale are also synchronised between the performers but in a slightly different way. Every time a performer changes sounds, or switches looping or autoplay on or off, this action is sent to every other iPad in the ensemble, but in contrast to the scale changes, which were *always* applied to the whole ensemble, the other iPads randomly choose to react to looping, autoplay or sounds actions 20% of the time. This partial synchronisation of features has the effect of assigning and reassigning the ensemble into sections as the performers find that their instruments sync up to other members of the group throughout the performance.

BirdsNest

BirdsNest (Figure 4) has a similar interface to MetaLonsdale but uses field recordings and bird sounds from Northern Sweden as the source sound material. This app was originally designed for a (different group's) "Sounds of the Treetops" performance at the Percussive Arts Society International Convention (PASIC) in November 2013. BirdsNest was later integrated into *Ensemble Metatone*'s performances and was used with syncing strategy that is quite different to MetaLonsdale.

The sonic material in BirdsNest is composed to allow each performer to create a journey through fields, a forest, up into the trees, and finally to a bird's eye vantage point of the whole landscape below. Visually this journey is communicated through a series of background images and collections of bird sounds and field recordings from the location as well as sampled percussion instruments such as wood block and xylophone, that complement this musical idea. Within each scene, the performer can shuffle through a subset of the sonic material using the "sounds" button, as well as use the "looping" and "autoplay" features. Unlike MetaLonsdale's focus on a sequence of scales, BirdsNest is based around a

series of sound *colours*, so the scales are not displayed to the user.

In contrast to MetaLonsdale where the synchronous changes to the app's sounds, tonality, and functions are triggered directly by the user, in BirdsNest, these are controlled by interaction with our ensemble-tracking server application, MetatoneClassifier. This software logs all touch interactions by the performers and classifies them every five seconds as one of nine percussive touch gestures [11] using a Random Forest algorithm [3] from Python's scikit-learn package. The software keeps track of each performer's history of gestures and identifies moments of peak change of gesture among the performers as points where it is likely that a new musical idea has occurred. Each performer's current gesture is returned to their iPad. When a new idea is detected, a message is sent to *all* iPads in the ensemble.

BirdsNest was our first app to have taken advantage of this system for real-time interaction with the ensemble performers. In solo performance, the forest scenes are advanced using the "sounds" button, but when the app connects to the server, this functionality is disabled. In network-enabled ensemble performances, the forest scene only advances when a "new idea" message is sent by the server. The other app functions are also influenced by the server interactions. Each iPad keeps track of previous gestures used by the performer, and when a performer stays too long on a particular gesture, the app switches one of the features on or off or spontaneously changes sound. The two networked interactions in BirdsNest are designed to encourage performers to continuously explore new gestural material. While it doesn't punish performers who stay on the same idea continously, it actively challenges them by changing their instrument, confronting them with a new sonic interaction.

Singing Bowls

Singing Bowls (Figure 5) is a ring-based interface for interacting with bell samples. Unlike the range of sounds available in the other Metatone apps, Singing Bowls allows the performers to interact with sounds generated from one bell sample. The app does, however, allow more expressive interactions with this sound where different kinds of touch gestures modulate the sound in a variety of ways.

Similarly to MetaLonsdale, Singing Bowls is based around a series of harmonically related musical scales. At any one time, a selection of three to ten pitches is available on the screen with each pitch represented by a ring and a text label. The pitch "setup", or collection of pitches available on screen, is generated separately by each iPad while staying within the same scale, so although the performers have the same harmonic location they each have a unique melodic space to explore.

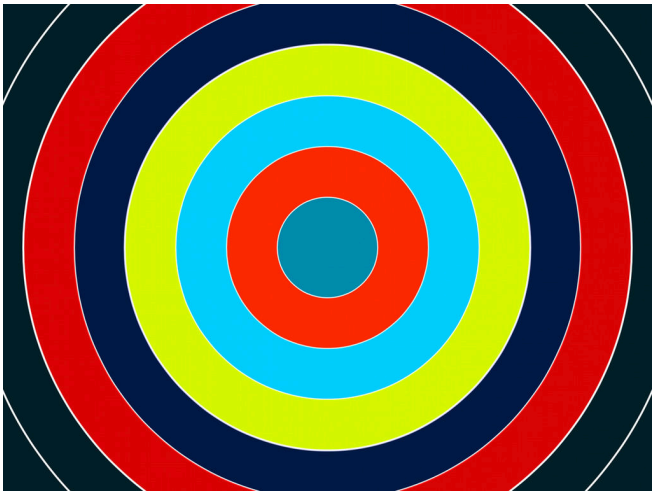

Figure 5. The minimalist UI of the Singing Bowls app. The available notes are divided by circles. When the performer activates a note by tapping or swirling, it pulses with a colour given by the pitch.

Tapping on a pitch ring triggers a short note at that pitch. A swipe sounds the pitch where the swipe began continuously using granular synthesis. The app can play one continuous note simultaneously with up to four tapped notes. To emphasise the different varieties of swirl and swipe gestures that the performers in *Ensemble Metatone* use, the app continuously calculates the velocity, direction and position of moving touches which affect synthesis parameters. The angle of the velocity vector of a moving touch point is used to modulate the pitch allowing different kinds of vibrato to be created with different movement patterns. The distance of the moving touch from the original touch point controls the degree to which a "crystal reverb" effect is applied to the continuous note, giving the performers a way to control timbre in real time.

The performers are given visual feedback when tapping or swirling in Singing Bowls. While the whole screen is a uniform colour when not played, when tapped or swirled each pitch pulses a particular colour following a system inspired by Roy de Maistre's artworks that relate music and colour [4]. When swirling, the intensity of the colour and speed of pulsing is connected to the performer's touch velocity and position.

Unlike MetaLonsdale and BirdsNest, the Singing Bowls app has no UI elements to change sound or scale. Instead, the app completely relies on the networked interaction between the ensemble of iPad apps and the MetatoneClassifier server software to present new notes to the ensemble. Each time a "new idea" message is received from the classifier, the app generates a new setup of notes. The app is hard-coded to choose two setups each from a sequence of three scales making six setups available before returning to the beginning of the cycle. Since the iPads all receive "new idea" messages together, they are always in the same place

in the sequence. Because each setup is created generatively, the performers continue to see new notes whenever a "new idea" message is triggered, even if the ensemble repeatedly advances through the whole cycle of scales.

Sync Strategies

In the Metatone apps discussed here, we have experimented with a number of strategies for syncing musical information during ensemble performances without disturbing fundamental control over their own music-making. Using a WiFi network as the interface for sharing data, these strategies used both direct connections between the iPads and an indirect connection mediated by our server software. In the following section, we summarise our sync strategies and connect them with experiences reported by musicians in *Ensemble Metatone* from their rehearsals and performances with the apps.

Tonality (scale)

The MetaLonsdale and BirdsNest apps featured a cyclic progression of scales that advanced randomly as the performers tapped the "sounds" button. If the performers tapped "sounds" approximately uniformly, it was possible that the scales would match up at times, but in practice, some performers preferred to try lots of different sounds while others stayed on a particular set. Our solution was to keep the scale in sync across the group. Whenever an iPad changed scale it would send an OSC message to the other iPads which would update their current scale, no matter which scale they were already on. The result of these synchronised scale changes was that the ensemble's performance followed a harmonic progression, one of the performers commented that "I thought it made everyone sound more cohesive".

App Functionality

Musicians don't generally expect that their instrument's functions would change under their fingers, but this is one of the interactions that we explored. MetaLonsdale had three UI elements, switches for the "looping" and "autoplay" features and a "sounds" button to shuffle the available sounds. With function syncing, when one performer turns looping or autoplay on or shuffles their sounds, a message is sent to every iPad in the group which then choose whether to make a change in response. The rationale behind this strategy for syncing was to stimulate the performers to try new ideas in tandem with others in the group. While these kinds of changes might feel disruptive to the performers, they can also be a fun musical challenge. One of our performers commented: "sometimes it will throw you a curve ball and you're stuck with something you don't want and you have to find a way of making something meaningful of it." On the other hand, the performers were concious of how their exploration might affect others: "I thought I was a bit of a bossy boots. . . because I kept pressing the change sounds button and then everyone would change."

Gesture Tracking

In performances with Singing Bowls and BirdsNest, the ensembles touch interactions are logged to a server running our MetatoneClassifier application. The server returns gesture classifications for each performer's interaction as well as information about the state of the whole ensemble, and in particular when the ensemble has undergone a significant change in gesture and might have moved to a new musical idea. Our goal for interaction with MetatoneClassifier was to provide interface-free experiences on the iPad apps where new sounds and notes are made available in response to the performers' musical gestures, rather than interaction with UI elements.

The interaction in BirdsNest was designed to change the app functionality when performers stayed too long on particular gestures. While this wasn't intended to punish the performers, they often regarded it as "annoying" and an unwelcome intrusion. In Singing Bowls, the interaction was designed to reward the performers for exploring new ideas. Each time the MetatoneClassifier identified a peak change in gesture, all iPads in the ensemble advanced to a new setup of notes. The performers worked together as an ensemble to trigger this response in the Singing Bowls app, reporting that they were "trying to get it to respond by copying and mimicing and getting everybody to change", and that "trying to do that made the piece nicer."

Conclusion

In the apps MetaLonsdale, BirdsNest and Singing Bowls developed for *Ensemble Metatone*, we experimented with strategies to enhance improvised ensemble performance by synchronising *musical information* across the group's iPads. Unlike other networked performance paradigms that focus on synchronising rhythm or distributing notes across several performers, our strategies sync the scales available to the performers across the ensemble, randomly match the app's functions, and track their gestural changes to encourage playful improvisations. In this way, we avoid disturbing the fundamental interactive paradigm of direct gestural manipulation of sound, where our group are already expert performers.

So do these syncing strategies help the ensemble reach the "group mind" state? The tonality and function syncing in MetaLonsdale and BirdsNest had a notable effect on the cohesiveness of performances. The performers were aware of the need to react to new settings and of the "bossy boots" effect that their own explorations had on other players. In Singing Bowls, access to new notes and tonalities is received as a reward for interesting ensemble interaction. In all of these scenarios, the actions of the performers were taken out of the performance space and embedded into the instruments so that a musical reaction was unavoidable.

It is questionable whether the kind of syncing described in this paper is always helpful to the players, the "curve

ball" situations reported by one performer could be frustrating. On the other hand, a level of disruption to the musical status quo could be warrented if the goal is to create stimulating performances. One musician appreciated this kind of interaction as he tended to "stick on the same thing for 20 minutes so it's good that you changed it."

While *Ensemble Metatone* may be able to produce successful music with any app, the strategies implemented in MetaLonsdale, BirdsNest and Singing Bowls seem to have allowed them to extend their practices in a way that existing acoustic or electronic instruments cannot. Sawyer [14] points out that the emergence of creativity in collaborative performances cannot be fully explained by individual analysis of the performers. Based our experience with the Metatone apps, we suggest the corollary that systems for computer supported group creativity must support the group activity. That is, the system must enhance the communications, negotiations, and gameplay that marks free-improvisations in order to extend the musicians' feeling of group flow.

Future Work

The strategies for synchronising musical information across an ensemble of iPad performers presented in this paper suggest several performance applications. In a networked performance situation where performers are not in the same location, instruments that build-in feedback on the musical direction of the other players could be cruial when regular visual and aural cues are limited. In educational contexts, the fact that performers must react to each other's actions could be helpful in training improvisation techniques. Ensemble performances with students or inexperienced performers could be gamified so that the participants must interact in certain ways to proceed to the next section of the piece.

For the immediate future, we plan to continue performing with our apps and introducing them to both novice and experienced musicians. MetaLonsdale, BirdsNest and an new version of Singing Bowls called PhaseRings are available in the iTunes App Store and most easily accesible at *Ensemble Metatone*'s website[2].

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[2] `http://metatone.net`