

# THE PULSE OF COMMUNICATION IN IMPROVISED MUSIC

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## ABSTRACT

The study of live human communication has, in recent years, led to a focus on our musical beginnings. These have been defined as an innate ‘communicative musicality’ evident from infancy (Malloch, 1999). The co-ordination of behaviours in oral music such as folk and jazz offers the researcher who studies the act of ‘music making’ a window to view the source of temporal competence and expressive intentional co-ordination.

**Aims.** To study the rhythmic co-ordination of sounds between jazz musicians improvising together. Points of synchronous activity are proposed as a means of accessing information regarding ‘shared pulse’ in improvised music.

**Method.** Quantitative methods have been developed to examine the rhythmic co-ordination of sounds between two jazz musicians improvising together within ‘blind improvised duets’, that is improvisations mediated by instrumental sound alone. Micro analytic techniques developed in the study of mother-infant communication are applied to process musical behaviour in digitally recorded sound. Patterns of synchrony are determined to a resolution of 100Hz after a measure of the changing loudness of sounds has been produced by acoustic analysis. Duets are also ‘barred’ and the corresponding times for moments of synchrony and the start of each bar are recorded.

**Results and Conclusions.** Variation was observed at the levels of both beat and bar/‘phrase’ suggesting that moments of synchrony are more than a cumulative summation of repeating rhythmic patterns. The interpretation of the findings in terms of structural elements of synchrony in the musical narrative support the view of ‘shared pulse’ as both a malleable, variable product of the moment to moment co-ordination of sounds between players and as an important structural device in the construction and expression of narrative.

## 1. BACKGROUND

Dynamic emotional exchanges in music provide a wealth of information regarding perception, cognition and ultimately the generation of motivated psychological time, the key to social communication in all animal species (Trevarthen, 1999).

The experience of listening to and playing music that is improvised is grounded in the shared sense of time in which the musicians are working (Iyer, 1998). It is in improvised music, particularly that derived from ‘oral’ traditions such as Jazz or Folk, that we find direct access to this skill of ‘constructive time sharing’ (Blacking, 1976; Iyer, 1998; Schögler, 1999). This study illustrates how the microanalysis of musical exchanges, particularly those that are improvised, provide the researcher with valuable information regarding how we are able to co-ordinate the spectrum of our mental times together in dynamic exchanges of narrative.

## 1.1. Studying Shared Pulse in Improvised musical exchanges

If musicians are to play together, they must be aware of a common pulse to produce the larger rhythmic structures with coherence, and although interdependent, it is pulse that generates the co-ordination of rhythmic forms.

A sharable pulse should be conceived of as a key component for communication in perception and action. The ability to communicate and negotiate a ‘shared’ pulse is a possible foundation for a general temporal schema in prospective control of a consciously moving subject moving in sympathy with others, and would underlie its essential role in communicative exchange or constructive time-sharing. Pulse in this sense is not the ‘isochronous’ timekeeper, but is ‘modifiable by experience’, sensitive to and capable of change, but at the same time it generates a reliable anticipation of activity that may engage self with world or self with other. The study of improvised ‘groove’ based music would appear to be particularly appropriate to this task.

“The experience of listening to music that is understood to be improvised differs significantly from listening to knowingly composed music. The main source of drama in improvised music is the sheer fact of the shared sense of time: the sense that the improviser is working, creating, generating musical material, in the same time in which we are co-performing as listeners.” (Iyer, 1998, p53)

When improvised musical interaction is recorded as it is created with no rehearsal or score, just spontaneous first time performance, this provides the researcher with data on the communication and co-ordination of motive impulses manifest in the forms of musical exchange.

## 1.2. Points of Synchrony

Research on musical ‘pulse’ confirms the importance of various forms of accent or dynamic change in its perception. In Deliege’s (1987) study, dynamic changes were identified as one of the common means of perceptual segmentation employed by both musicians and non-musicians. In musical theory, accents can be ‘melodic’ as well as ‘dynamic’, the dynamic accent being a generator of salience accessible in all modalities of music, common to both percussive (drumming traditions of Africa), and harmonic (Western tonal music) and is accessible by musician and non-musician. Thus, dynamic accents do not require the complex control of instrument or voice with regard to pitch and timbre but can be expressed through the changing intensity of sounds, and as such are accessible to infant and adult, jazz improviser or naïve listener. A simple way for two musicians to mark a dynamic accent in their joint performance is for them to produce synchronous events in the streams of their behaviour.

## 2. METHOD

‘A strategy for analysing the generators of common pulse in musical performance’.

The synchronous expression of two individuals performing a duet identifies a point in time as salient to both the musicians (Cooper and Meyer, 1960) and this event can be perceived as pertinent to the shared pulse they are creating. For musicians to produce a series of synchronous events they must share a common understanding of what the shared pulse is and be employing that to direct their performance. In improvised performance the synchronicity itself is impulse driven and expressive (Schögler, 1999). The action is both structural, in terms of organising the behaviour, and communicative, in conveying the organisation. The synchrony is achieved as a dynamic product of the performers’ conscious purposeful action and interaction. Utilising perceptual feedback in the prospective control of action, they come together in their activity to meet at precise points in time. Each point of synchronous contact in a performance is specified, as a significant point in the narrative of musical gestures that they are imagining and sharing. Being ‘together’ in the production of their activity they are able to synchronise their expression of the musical idea purposefully anticipating the perception of each dynamic ‘accent’ or ‘stress’ point in the piece.

A musical sequence of points of synchrony is proof of the prospective control of action both within and between improvising musicians. It follows that the study of synchronous events in improvised duets may make it possible to explore how the musicians in their joint performance create pulse. To eliminate extraneous variables the ‘blind improvised duet’ paradigm can be employed (Schögler, 1999). These are improvisations mediated by instrumental sound alone that when recorded produce three audio files for each performance; the combined sound of the two musicians and the isolated sound of each musician - see figure 1 in image file [IMAGE1.PDF](#). These recordings can then be subjected to microanalysis.

In this study five duets performed by musicians separated in two studios linked by sound alone and employing the following instrument pairs were recorded for analysis: 1) Kit drums and electric bass; 2) Kit drums and double bass; 3) Kit drums and electric guitar; 4) Electric guitar and double bass, and 5) Kit drums and double bass. Each was recorded digitally using a Roland VS 880 hard disc recorder.

In the examples recorded the musicians played repeating rhythmic structures setting up ‘grooves’. If the synchrony observed between musicians is purely an additive result of how the rhythms they are playing combine, then the patterning of synchrony should be regular in relation to the repeating rhythmic structures being played. However, if the inter synchrony observed between individuals is a result of the moment by moment negotiation of a malleable shared pulse then variation should occur. The patterning can be observed in terms of two frames of reference; the narrative of the piece (time from the start of the duet), or the repeating bar structure (time from the start of the bar).

## 2.1. How to extract synchrony

To study perceived moments of synchrony, a measure of the perceived intensity, or loudness, must be produced for the individual performance of each musician and their combined sound. Subsequent inspection of the changing loudness of each individual performance will show moments of synchrony as co-occurring peaks in loudness. In the microanalysis of infant communication, algorithms have been developed to extract different qualities of sound such as pitch, timbre and loudness (Malloch, 1999). These techniques were applied to the recordings of the improvised duets to produce a measure of the changing loudness (in sones) with a resolution of 100hz for each audio file. These sones files were then used to determine points of synchrony in the performances by identifying co-occurring peaks in sones.

All 5 improvisations were inspected longitudinally and the time for co-occurring peaks in loudness (for the isolated sound of each musician) was recorded. Each performance was also ‘barred’ and the start time for each bar recorded. A bar is defined in the activity of the two musicians as they produce repeating rhythmic groups of notes or sounds. The barring technique attempts to avoid a priori concepts of a regular ‘metre’ or ‘beat’. In accord with theories of music cognition and perception, the beginning of a bar can be detected through identifying an ‘accent rythmique’, defined by Mathis Lussy as a dynamic emphasis placed at the beginning or end of the phrase or sub-phrase (Green, 1994). Through systematic audio inspection ‘barring’ can be ‘content driven’ by the actual activity of the musicians, not by an externally conceived overall tempo or metre. Bars are identified through listening to the combined sound for repeating rhythmic phrases in the behaviour of the musicians. By audiovisual inspection of the waveform, which shows the oscillation of sound energy around zero, it is possible to identify the specific oscillation that represents the sound made at the beginning of the bar. The beginning of each bar can then be accurately determined during audio visual inspection by a search for zero crossings in the wave file. This is a standard professional audio editing technique in preparation for segmenting wave files.

## 3. RESULTS

The patterning of synchronous activity between musicians is examined at the level of both the narrative of the piece and the repeating rhythmic structure set up in the ‘groove’

### 3.1. Synchrony Maps

The plots of synchrony against time from the start of the duet are presented in the rich text file [IMAGE2.PDF](#). It is intended to examine if synchrony patterns are merely a product of the chance manner in which the different sequences of behaviour combine and the alternative hypothesis that synchronous events represent the expression of co-occurring impulses, which therefore provide information regarding the changing nature of the ‘shared pulse’. It is expected that patterning at a micro-level ‘within’ bars define minimal units through joint expression of successive pulse events. It is also predicted that increased interactional synchrony will be observed in relation to points of qualitative change in

the performances (Schögler, 1998, 1999). The patterning of synchrony will inevitably be a function of the pace or tempo in relation to the length of the duet - a very long slow piece will show less bunching of events and vice versa.

The synchrony maps [IMAGE2.PDF-Figure:2] show points of synchrony represented as vertical black lines against time from the start of the duet in seconds on the X axis. On first glance Figure: 2 [IMAGE2.PDF] appears to show little similarity both within and between duets. The apparent lack of a distinct hierarchical structure is most interesting. If the synchronous events under examination were merely a product of the manner in which the two rhythms of the musicians combine then one would expect these events to recur at either bar or phrase level. In each duet the playing of the musicians is highly repetitive in a rhythmic sense, and despite this rhythmic repetition there seems to be distinct variation present in the structure of synchrony throughout each duet. The synchrony maps are unique and particular to the duet they represent.

When one considers more general features of the synchrony maps, all five show periods of low synchrony building up to periods where lines of synchrony are more densely packed, as shown by dark bands recurring throughout each duet. These dark bands represent periods of intensified interactional synchrony. These recur in cycles of between 2-3 seconds to the longest in duet 5, which is around 75 seconds in length.

The patterning of synchrony appears to relate to the co-ordination between the two musicians involved in a duet, mapping points of synchrony in a longitudinal manner allows this facet to be viewed in terms of the narrative elements of the interaction. In each representation we have beginning or initiation followed by cycles of alternating relaxation and excitement in increased levels of synchrony. The synchrony maps striking resemblance to DNA profiles is well noted and such a comparison is illustrative of the particular story being told by the tracking of synchronous events. The maps show how the behaviour of the two musicians fits together, negotiating theme and change to engage each other in a co-ordinated dance of expression. An important feature of these synchrony maps is the lack of metronomic regularity. The more 'elastic' structures evident indicate that the points of synchrony represent more than the simple additive sum of two streams of patterned behaviour.

It is possible that variation in bar or phrase length is responsible for the distinct lack of regularity observed in the patterning of synchronous events. Consequently data gathered in the 'barring' of duets was used to examine the variation in bar length within duets.

### 3.2. Bar length and Synchrony by Bar

There are two principle factors illustrated in the data on bar length (IMAGE2.PDF - see Figure 3). There is evident variation in the length of bars (repeated rhythmic groups or phrases) and this variation is not random error introduced through inefficient co-ordination of the individuals own motor skills or between the musicians' musical gestures. Tempo, metre and essentially pulse are malleable evolving forms generated as both predictive schema and feedback through communicative exchange.

The variation in bar length demonstrates variation in the underlying or 'shared' pulse mediating the exchange between the two musicians. These variations occur not only at the level of pulse and bar but also show systematic patterning at a narrative level, Figure: 3 (IMAGE2.PDF). The variation in duration was subjected to statistical analyses and although significant correlations were observed and each of these is evident from inspection they are not predictable in terms of simple rules. A significant negative correlation shown in duet 2 ( $r = -0.372$ ,  $p < 0.05$ ), where bar length decreases with bar number (position in duet), and a significant positive correlation shown in duet 3 significant ( $r = 0.828$ ,  $p < 0.01$ ), do not allow accurate prediction of bar length from position, but do allow a general observation to be made regarding the relationship between phrases at the start and at the end of the piece.

#### 3.2.1. Synchrony by Bar

Extracting synchronous events provides the researcher with the chronological time of each point of synchrony measured from the start of a particular duet. The corresponding maps of synchrony allow individual points of synchrony to be identified and the relationships between successive synchronies to be examined. This process is independent of the rhythmic grouping identified by the 'content' barring procedure that provides us with the chronological time of the beginning, and end, of each bar. The relationship between the synchronous events and the narrative structure the musicians create through their joint activity can be examined by combining the information from these two procedures as follows. To obtain comparable results between phrases or bars regarding the position of each point of synchrony in a phrase, an index of the position of the point of synchrony is used (calculated from the time from the start of the bar of the point of synchrony / the duration of the bar). This measures the relative position of the point of synchrony in a bar. Circular histograms can now be used to examine the frequency distributions of standardised points of synchrony across bars, in Duets 1-5 [IMAGE3.PDF]. A resolution of 0.03ms is used to define recurring moments of synchrony in accordance with previous research on temporal acuity (Wittman and Pöppel, 1999).

Each duet shows many points of synchrony occurring in a non-repetitive manner, and these are represented by those lines confined to the central concentric circle of the rose diagram. Each duet shows a number of recurring moments of synchrony or 'accent points' in the rhythmic structure of the bars created by the musicians. The patterns of recurring accents vary from duet to duet, suggesting that the synchronous activity is a product of the interaction created in each performance, and negotiated bar by bar.

There appear to be two distinct levels of patterning in synchronous activity. There is an initial or 'primary' level, represented in the inner circle, of accents that are specific to the bar in which they occur, and there are points of synchrony that mark a point of emphasis that the musicians repeat in different bars. This second effect suggests that moments of synchronous activity are not just important at the 'primary' level where the musicians negotiate the shifting pulse generated between them but they also play a structural role in the narrative of that interaction showing

consistency across bars with regards to the rhythmic position that they occur. All duets show repeating moments of synchrony with a frequency of at least 2 and some with frequencies of 3 and 4.

#### 4. CONCLUSION

Moments of synchronous expression have been shown to be valuable sources of information in the study of shared pulse in improvised music. While each internally co-ordinates the complex sequences of action required in their individual musical performance, the two musicians must also constantly negotiate one another's expression and construct a common pulse through their combined activity. The manner in which variation occurs at both at the level of individual synchronous events and in the length of bars and phrases demonstrates the natural elasticity of the shared pulse in improvised musical performance. The function of pulse in music is to provide a future sense of events by which it affords perceptual control of complex sequences of individual and joint activity, but that future is only perceivable through our engagement with it as both audience and performer. The perception of pulse makes both control and appreciation of joint activity possible and is accessible through moments of synchronous expression in improvised music. We conclude that there must be perceptual information immediately available to the musicians regarding the changing nature of the pulse, from which they can regulate their activity in order to produce a coherent musical performance.

This work represents first stage in a communicative analysis of improvised music. Work is currently underway to extract the perceptuo-motor information available in the streams of musical behaviour through an application of Tau theory and Tau coupling analysis (Lee, 1998). The results of this will be presented at this meeting.

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