Cognitive Processes in Musical Improvisation: Some Prospects and Implications

Roger T. Dean* and Freya Bailes, australYSIS*, and MARCS Auditory Laboratories, University of Western Sydney, Australia.

Improvisation in the arts is most notably a real-time process, in which the pre-formed and the unfamiliar can be brought together as a piece is made, potentially synthesising emergent structures and meaning (Bailey 1980; Smith and Dean 1997; Sawyer 2003). The Improvisation, Community, and Social Practice project (www.improvcommunity.ca) envisages that improvisatory activities can play useful roles in building social interactions, community and social policies, as evidenced in many articles in its academic journal, Critical Studies in Improvisation (www.criticalimprov.com). In order to understand how improvisatory activities operate, and how they might be marshalled for such purposes, it is at the ground necessary to understand the cognitive processes that individual improvisers draw upon, and how they do so when improvising with others. Even when improvising alone, these cognitive steps must involve both perception and production, and the quantitative (but not necessarily the qualitative) complexity of these components is amplified as the number of improvisers increases. As we have noted (Smith and Dean 1997), an improviser may conceivably modulate between a highly ‘sensory’ stance, in which they attempt to be aware of and responsive to most of the actions of their fellow participants, and a relatively ‘non-sensory’ stance, in which they minimise such awareness (and hence such responses too). Although it is well established that attentional focus can vary, there are as yet no data that address the extent to which an improviser can achieve such modulation of ‘sensory stance’.

This article is no more than an elementary introduction to some of the interesting cognitive issues in musical improvisation, to some of the few empirical studies already available, and to some of the current studies under way or to be expected. In a final section we will point briefly to the questions of how these cognitive processes can allow creative interplay its fullest range, and how this might contribute to social discourse in a broad sense. It is useful to note that ideas of improvisation in theatre, notably those of Keith Johnstone (Johnstone 1979), focus quite directly on the psychology of inter-personal and group interactions, as these are embodied and reflected in verbal exchange. The ideas of status, role-playing and related interactions developed in the context of theatre improvisation may be productively applied within musical processes, even though their expression does not use the highly referential medium of language, but the less referential discourses of sound.

A simple framework for analysing musical improvisation

A few ideas can be placed together to provide a simple description of group improvisation, which can form a model capable of providing empirically testable predictions of the kind cognitive scientists can work with. A broad framework, together with ideas for computational modelling, flowed from the much broader work of Philip Johnson-Laird on creative processes and brain activity (Johnson-Laird 1991; Johnson-Laird 2002); such frameworks have since been reviewed by others (Kenny and Gellrich 2002). As a bass-player, Johnson-Laird implemented a computational model of improvisatory jazz bass-line generation, of whose products he remained quite critical: he seemed to somewhat dislike both the relatively limited pitch structures and the rhythmic monotony it produced.

One related idea about improvisation, probably first well developed by Jeff Pressing (Pressing 1988; Pressing 1998), and subsequently applied and extended in our practical and analytical/theoretical conceptualisations (Dean 1989; Dean 1992; Dean 1992; Smith and Dean 1997; Dean 2003), focuses partly on how the segmentation of musical material is achieved in an improvisation. Improvisation may or may not use a pre-formed referent, such as the 12 bar harmonic pattern of many blues, or the 32 bar harmonic pattern of many popular songs that jazz musicians interpret. Whether or not there is such a repetitive referent, the issue of segmentation is one of how a group of improvisers transition between successive states which are distinct (even though they may share the 32 bar cycle). One of the suggestions is that moments of instability or of abrupt or substantial contrast, in terms of musical material, may be generated repeatedly as a piece progresses, and if accepted by a majority of the improvisers, and incorporated into their own generative processes, then create the transition into a new
segment. On the other hand, if rejected (or disregarded) by the majority, which might include any improvisers behaving in a ‘non-sensory’ manner, as well as others who evade the new material more actively or consciously, then no full transition occurs, and no substantial new segment is initiated.

Such a simple description immediately leads to musicological and cognitive predictions. For example, statistical distinctions (such as new melodies or harmonies provide) should occur between the materials of successive segments; and transition periods themselves, whether aborted or successful, will show transiently increased variability of some of those statistical features that are ongoing at the time. Pioneering studies of such statistical features of two solo keyboard improvisations were published by Pressing, with particular emphasis on how the presence of an external rhythmic pulse influences the temporal patterns and their correlations (Pressing 1987). Correspondingly, it can be expected that an improviser who attempts actively to create a transition in a group improvisation performance may show psychological arousal at the point of so doing, detectable in principle by psychophysiological measures, such as skin conductance, heart rate, and perhaps by the more complex and restrictive neurophysiological methods of electro-encephalography (EEG), or by neuro- and vascular-imaging techniques. Lastly, it can be envisaged that at least a sensory improviser would have perceptual awareness of such an attempted transition, and whether it was successful, at the time it happens. This could be defined during performance, for example by a participant who used one hand to represent continuously impressions of such changes, and another for the purpose of contributing to the sonic stream. While such a dual task is broadly impractical, and has not been reported in any substantial experiments to our knowledge, improvisers could also listen to recordings of their improvisations in order to report their impression of such perceptions.

These models and predictions can be substantially elaborated, but the scope of this article does not permit that. However, it is worth mentioning that it is not a great conceptual jump to indicate that the so-called Geneplor (generate-explore-select-refine) model of creativity at large (Finke, Ward et al. 1996) involves similar processes. Such models add a somewhat arbitrary restriction on the nature of the process in which transitions are accepted, describing them as ‘selective’ steps — note the teleological or evolutionary overtone — implying that in some sense an ‘improvement’ might be achieved as a result of the acceptance of the transition and the new segment (which may have some analogy to a beneficially mutated gene). On the short term and immediate temporal scale, the concept of ‘flow’ is a metaphorical description of the ongoing psychological state which permits such transitions/creative evolutions to occur (Csikszenmihalyi 1996), and which has been applied to free jazz (Mazzola and Cherlin 2009). On a larger scale, the iterative cyclic web of research-led practice and practice-led research which we have described and theorized (Smith and Dean 2009) is equally an application of such processes. Within musical improvisation at least, there need be no such expectation that an ‘improvement’ should result from a transition, but rather that it may simply represent temporal contrast.

Let us return to the cognitive components of individual and group improvisation, to discuss the limited empirical approaches that so far have been taken to understanding whether the framework outlined has any relevance.

**Component processes in musical improvisation**

Another layer of insights provided by Pressing concerns the motoric actions which musical improvisers have to provide. He noted that events in a piano or saxophone improvisation, group or solo, can be extremely fast, perhaps up to 20 per second. A body of literature suggests that in this circumstance it would be impossible for every individual event to be separately planned and executed, but rather that there must be a grouping of events into what are cognitively single actions, and/or their achievement by a level of automaticity. These are not issues specific to musical improvisation, though they are certainly heightened even in comparison with those of expert sports, because some of the component events may be relatively unfamiliar, even while many others are familiar and well practiced. There is a large literature on this issue, and though not generally directed towards improvisation, its implications are readily apparent.

These motor events go into the generation of musical motives, material which can be shared, repeated, and then developed and exchanged across members of a performing group. The very few
published empirical cognitive approaches to these processes have involved extremely simplified and non-ecological improvising conditions with solo performers, and have sought to identify brain regions in which neural or vascular activity may be changed by contrast with simpler or non-improvising performance conditions. For example, Limb et al had their jazz-oriented improvisers perform scales and to improvise on a very simple 12-bar blues with a pre-recorded accompaniment (Limb and Braun 2008) in order to undertake fMRI studies of regions of the brain whose blood flow was activated differentially in the chosen conditions. fMRI involves substantial restrictions of the movement and immediate environment of the participant (they cannot be at a piano keyboard, for example). A special miniature keyboard was used, as was the case also in another fMRI study, in this case of classical pianists (Bengtsson, Csíkszentmihályi et al. 2007) who were allowed to improvise ‘freely’ in one of the three main conditions studied, but actually required to do so on the basis of very simple tonal melodies. These musicians were not claimed to have any special experience in improvisation. Related fMRI experiments by Berkowitz (Berkowitz and Ansari 2008; Berkowitz and Ansari 2010) focused on the continuation of the traditions of classical cadenza and accompaniment improvisation (as analysed in Berkowitz’s recent book based on Pressing’s framework: (Berkowitz 2010)), and again involved very simple referent pitch patterns. The later paper describes ‘deactivations’ of the right temporoparietal junction of the brain, which the authors suggest may be a mechanism for inhibition of ‘stimulus-driven attention’, and thus may relate to the concept of non-sensory improvising we have proposed; however, the relationship between vascular activation in fMRI and neural activity is complex and variable, and hence interpretation is not simple (Logothetis, Pauls et al. 2001; Logothetis 2008). Imaging experiments mostly require simplified conditions and restricted circumstances both for precision of control of the experimental conditions (which is always necessary in many respects, and desirable in most), and also to permit the use of some techniques in which position and movements must be heavily constrained if the equipment is to be adequately functional. Portable EEG devices are now available, and these will gradually supplement the information from the more physically restricting techniques, as do skin conductance measures (see below).

There is considerable musicological literature on motivic development in say, Charlie Parker’s or John Coltrane’s soloing, but there is relatively little on motivic development in free improvisation. Largely lacking too is systematic study of musical exchange operating in an inter-individual manner within group improvisation: the classic musicological work on improvised structures in free jazz (Jost 1974) largely deals with higher level and pre-composed elements. In one book, one of us (Dean 1992) deals in some depth at least with various sophisticated group rhythmic interactions (for example in the Miles Davis 60s quintet). But there are huge gaps in such studies. What is much needed is the cognitive study of group segmentation/transition processes, and to this end we are currently undertaking elaborate experiments with experienced solo (and soon duo) keyboard improvisers using a MIDI-equipped grand piano in a situation of reasonable ecological validity, i.e. one akin to many in which professional improvisers participate. In these studies, the improviser plays a series of improvisations, each of about 3 minutes. First a free improvisation, then a series of improvisations in which an A1-B-A2 referent is provided (for example ‘improvise sparsely-densely-sparsely so as to form three segments’), interleaved with others in which segmentation is requested but no specific indication as to how to achieve it is provided; and concluding with another free improvisation. In contrast to some of the loose terminology of ‘free improvisation’ and the restricted referents used in the imaging experiments we have summarised above, our ‘free’ conditions really allow the improviser to do as they will, while playing the piano on the keys. The only restrictions are that they have to pedal with the right foot only (as the left ankle is occupied by some physiological detectors), and have not to use the strings of the piano or its body directly as sound sources, but only to play on the keys. We record audio, MIDI (information as to keys performed and their velocity, i.e. intended loudness; and as to pedalling), video, and skin conductance and control information about movement of the ankle on which the physiological detectors are placed, to detect any artefacts that may result from sudden movements. Skin conductance provides information about activities of the autonomic nervous system, which amongst other things can reflect psychological arousal. We analyse the musical results to determine segmentation, initially on the basis of the provided referent instructions, and later using a battery of parameters, since in many cases we do not know what
basis of segmentation has been adopted, and in the free improvisations we do not know a priori whether there is any statistical segmentation or not. Then we assess whether the segments detected by this computational approach are paralleled by those detectable within the skin conductance response, predicting that they should be. Lastly, the improvisers listen to some of their performances, and using a computer interface developed for the purpose, give a continuous assessment of the extent of musical change occurring as the piece progresses (c.f. our use of this interface in other work to define perceptual responses to electroacoustic compositions: (Bailes and Dean 2009; Dean and Bailes 2010 in press). In work to come we will also obtain assessments from other uninvolved listeners, both of perceived change and of affective properties of the music, so that these can also be tested for the predictions of our model.

For example, we predict that improvisers will identify segments on the basis of the cumulated continuous assessment of change, and that these segments will coincide with those revealed by both our computational analyses of the musical material, and of the skin conductance. So far in our work some key predictions have been strongly upheld; that we can detect the segments computationally, and that they coincide with segmentation of the skin conductance as well as with the segmentation of change as perceived by the improvisers themselves.

We hope that this approach will also allow us to determine aspects of the inter-improviser interactions which occur during transition and segmentation, using pairs of improvisers, both providing skin conductance and separate MIDI data. Such interactions may distinguish ‘leader’ from ‘follower’ roles, these roles quite likely being exchanged between the participants as a performance progresses. For example, the skin conductance patterns when an individual leads a successful transition may be different from those when they follow one initiated by the other. We also wish to test the idea of sensory and non-sensory ‘stances’ raised above, by conducting some improvisations under conditions where the improvisers successively can or cannot hear each other’s playing as an improvisation progresses.

**Improvisation in Society**

Many of the ideas above can be transposed, with caution, so as to be applied to improvisation in the arts beyond music, or in verbal discourse beyond the arts. It is at this level that the potential utilities of improvisatory processes come to the fore, and we can ask how they may contribute to social interaction and policy development, as is the intent of the ICASP project. Linking the cognitive and the social is an important task for the future. In a current article (Critical Studies in Improvisation: revision under review 2010) we note some of the ways that segmentation through acoustic intensity profiles, which are shared across the Afro- and Euro-logic streams of musical improvisation (Lewis 1996), and across many other forms of music, may provide a transcultural vehicle. (We have already illustrated such intensity segment patterns in earlier work which involved a small number of electroacoustic improvisations (Dean and Bailes 2010).) The vehicle of shared intensity profiles may be operative both in musical and speech sound, and be something that can be harnessed to enhancing dialogic processes involved in idea generation and policy formation, into an even more productive set of social tools. As mentioned, in other work, we have shown how an improvisatory and iterative cyclic web of creative and research practice may similarly be important for the development of ideas in a higher education context (Smith and Dean 2009). The broader and more widespread application of such selective cycles is an optimistic ideal for the future.

**Published:** 2010.


