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Chapter N:

Creativity Studies and Musical Interaction

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1 Introduction

It is difficult to talk about creativity—musical creativity in particular—in a scientific context. Creativity has been addressed for some time by various research communities in social science, psychology, cognitive science and artificial intelligence, with the surprising effect of turning an elusive word into a research theme, and sometimes even into a fully-fledged scientific "issue." There are now formal definitions of creativity, theories of how it can happen, how it can be explained, and even how to train oneself to become more creative. As a consequence, creativity has been trivialized to a point where many researchers profess to find it in the behavior of virtually anything human or artificial. This dense but paradoxical landscape makes it difficult to say something new about creativity, let alone something creative.

One of the difficulties of this endeavor is, in our point of view, probably related to the desire of measuring the output of humans objectively with the goal of directly assessing the creativity of the performer as such, in the absence of a precise notion of creativity. Actually, most of the works in creativity assessment consist of proposing both a definition of creativity and a method for its assessment. This desire is itself motivated by the need to write scientific papers, where formal evaluations and assessments have become a necessity. From our point of view, the danger of such an approach is that it tends to formulate definitions that exclude the most important and interesting aspects of creativity—mainly subjective ones—and favors scholastic studies on relatively marginal phenomena, resulting in shallow analysis of musical features and behaviors.

Although we agree that creativity can be reflected in objective productions, and can possibly lead to some sort of measurement, the position we take in this chapter departs from traditional creativity studies in at least two ways. First, we address creativity from a subjective viewpoint, as a personal feeling of creating something new and interesting, associated with some specific context of production, and we position this stance in the context of creativity studies. Secondly, we focus on a non-natural form of musical activity - interactions with computer systems - as opposed to composing or performing in traditional contexts.

2 Creativity Studies and Computer Interaction

This section reviews the state-of-the-art in creativity studies concerning the use of computers for musical activities, with a particular focus on interactive systems.

2.1 From Mozart to myself

The trivialization of the concept of creativity, although debatable, has one major benefit. Indeed, one of the most productive "results" of creativity studies is probably to have progressively reduced the scope of the concept of creativity from the studies of well known geniuses to individual, routine forms of creation. Boden (1990) for instance distinguishes creativity of a community from creativity of an individual (her so-called historic and psychological definitions of creativity). The reduction of the scope of creativity is useful because individuals can be studied with more precision than communities. At the highest level, creativity can describe phenomena happening at the scale of music history: the history of music is filled with geniuses of all kinds, with sharp transitions, revolutions, intertwined with periods of stylistic stability, or sometimes regression. The works of Gesualdo, for instance, are still considered by many musicologists today as definitely innovative, and still considered as some sort of mystery in the history of Baroque music. Beethoven composed many melodies which have spread throughout Western culture and hold a place in music history as unique works of art. More recently, the Beatles have revolutionalized popular music by breaking through many musical dimensions, borrowing elements from classical music to invent a new musical language. However, asserting that these artists have been extremely creative is probably as fair as it is trivial.

On a more specific level, one can try to distinguish what makes a given work so special or creative with regard to other works by the same artist. But to our knowledge such an endeavor has rarely been attempted with success and precision. This very task of identifying where creativity lies raises so many issues (concerning consensus or lack thereof, analysis methods, etc.) that it is probably unsolvable. Since the creativity of great artists makes sense only within a given culture, it probably *is* a substantial part of the culture, and consequently there may not be much else to say about it from a scientific viewpoint.

In this work, we aim at further reducing the scope of creativity by focusing on tasks involving a normal performer and computer software, without dissociating the two. In some sense we introduce a new focus for creativity studies: systems composed by a human and an interactive machine.

2.2 Enhancing creativity

The idea of enhancing creativity has received particular attention in creativity studies. Although the very idea is debatable (after all, why would one want to enhance creativity in the first place, and more importantly are there efficient ways of achieving such an ambitious goal?) enhancing creativity has however been addressed for a long time, and it is considered normal today to target such a goal in the classroom for all sorts of activities. Nickerson (1999) for instance, reviews the main approaches in creativity enhancement in the classroom. It is important to note that most of the approaches in creativity enhancement are based on specific organizations of the curriculum, e.g. brainstorming sessions, ways to facilitate divergent thinking, etc. Our approach here is not to consider particular organization of teaching, but to consider the issue of creativity enhancement from the viewpoint of system design, i.e. how to design computer systems that can lead to creativity enhancements in laymen or children.

2.3 Creativity studies focus on existing musical practice

One important question in creativity studies concerns the assessment of systems that enhance creativity. Creativity has to do with the eventual production of artefacts which are clearly visible and observable. In our context, the artefacts are music productions, which can be represented in various ways, such as scores, audio or video recordings. Webster (1992) reviews the main approaches in assessing musical creativity, including psychometric studies, cognitive studies, analysis of music content, as well as analysis of the music composition process. Worth noting in these studies are the experiments on analysis of music content performed by Loane (1984), who discusses children's compositions in relation to their cultural environment. The experiments by Bamberger (1977) are very interesting in our context because they highlight the central issue of *decision making* in composition. Flohr (1985) studied more particularly music improvisation by children, and proposed musicological analysis of these improvisations performed under various constraints (e.g. free improvisation or improvisation by mimicking input rhythm, melodies, etc.).

Assessment in all these approaches is based on a "direct" production of users, i.e. the situation where the user produces some output, with no system feedback. The production can be free (improvisation) or constrained (e.g. in response to some stimulus), but the situations studied are always based on a simple user to production chain.

Webster (2001) reviews the use of computer technology for music education and even dares to make predictions or suggestions for the development of future technologies, but concentrates mainly on straightforward techniques of computer-based composition and performance. Such a position is hard to defend because the developments and innovations in music technology are, by definition, unpredictable, much the same way that musical works created by creative composers are unpredictable. In any case, they have never been the results of suggestions by scholars.

2.4 Assessing creativity

2.4.1 Assessing the creativity of music content

Many studies of creativity have addressed the issue of assessing music content directly. Music lends itself quite well to various sorts of measurements, in particular tonal music, because of the many dimensions of music that have been formalized throughout the history of tonal music. Pitch contours, rhythm patterns, harmonic modulations, etc. are easy to spot and measure, and several authors have used these dimensions of music theory to assess the productions of various categories of users. The relation to creativity, however, is not clear (e.g. Folkestad et al., 1998). Simple counterexamples suffice, in our view, to dismiss content analysis for assessing creativity in the large. For instance, there have been numerous attempts at copying the style of well known composers (both classical and pop music). These copies have, by definition, the same musical elements (patterns, etc.) that musical analysis would detect, but are never considered as interesting as the originals and certainly not as creative. In these conditions, it is difficult to consider direct content analysis seriously for creativity assessment.

As we will see below, however, content analysis can be useful to compare outputs produced by the same user under different circumstances (e.g. with and without the use of a computer system).

2.4.2 Flow and music creativity

Besides assessing content, one can observe psychological reactions of users in psychometric studies, for example. One particularly relevant aspect of subjectivity concerning creativity is the notion of personal enjoyment, excitement, and well-being.

To this end, we consider Mihaly Csikszentmihalyi's theory of Flow (Csikszentmihalyi, 1990). This theory is an attempt to describe the so-called "optimal experience" as experienced by creative people. The word Flow itself describes the psychological state creative people claim to reach when they are engaged in their favorite activity. The reason why we think the theory of Flow is well adapted to assess our musical experiments is that it captures, or at least attempts to capture, what we think are crucial elements of the creative process, in particular excitement, surprise, and the gradual transformation of the musical activity into an autotelic activity, i.e. an activity which is or becomes *self-motivated*.

Csikszentmihalyi's notion of Flow describes the so-called optimal experience as a situation in which people obtain an ideal balance between skills and challenges. Two emotional states of mind are particularly stressed in this theory: anxiety, obtained when the skills are clearly below the level needed for the challenge, and boredom, when the challenges are too easy for the skill level. In the middle lies Flow. Other states can also be described in terms of balance between skills and challenges (see Figure 1). One important motivation for studying Flow lies in the origin of well-being which, according to Csikszentmihalyi, is to be found in particular forms of interactions:

> "The phenomenology of Flow suggests that the reason why we enjoy a particular activity is not because such pleasure has been previously programmed in our nervous system, but because of something discovered as a result of interaction" (Csikszentmihalyi, 1990, p. 189).

This point is particularly important in our study because we aim precisely at designing new forms of interaction that may enhance creativity by providing Flow experiences. Of course not all forms of interaction are flow-generating, and it is precisely the subject of (Pachet, 2004) to propose a particular architecture for building computer systems that can generate flow experiences.

The theory of Flow has had some success in experimental psychology over the last 10 years, in many different domains. It has been considered for music also for obvious reasons. For instance, Sheridan and Byrne (2001) advocate the use of the theory of Flow as an assessment measures for musical creativity in classrooms. Byrne et al. (1999) examines possible relations between Flow and musical outputs of students in composition, using the technique of Experience Sampling Forms (Csikszentmihalyi, 1988). These studies tend to show that there is indeed a relation between Flow and creativity, at least in standard music composition tasks as performed by music students.

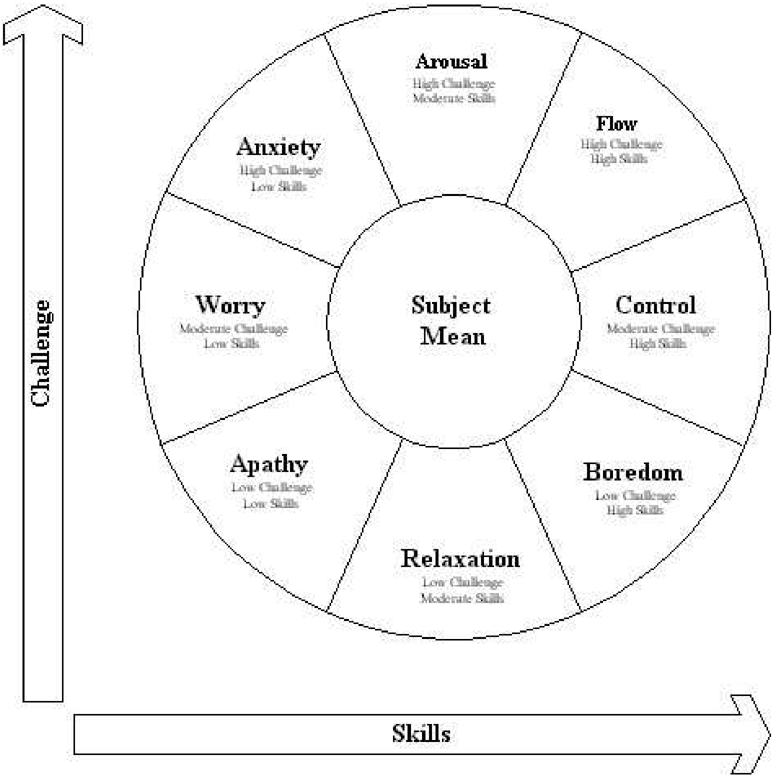

Figure 1. Csikszentmihalyi's Flow diagram describes various emotional states such as boredom or anxiety according to the balance between skills and challenges for a given activity.

More precisely, Csikszentmihalyi describes the state of Flow as consisting of several fundamental traits where the balance between challenges and skills is probably the most important. Other traits are the following:

- *Focused attention*
- *Ease of concentration*
- *Clear-cut feedback*
- *Control of the situation*
- *Intrinsic motivation*
- *Excitement*
- *Change in the perception of time and speed*
- *Clear goals*

Because Flow is defined using relatively precise traits, one can envisage precise criteria for evaluation. The state of Flow is in fact rather easy to detect. We consider in the work that Flow is central to the design of interactive system that enhance creativity: if we consider Flow as a prerequisite for creativity, then creativity enhancement can be achieved indirectly by augmenting the chances of creating Flow experiences.

2.5 Playing and composing music with computers

In this section we review some of the major developments of computer systems for assisting musical composition and improvisation and their links to creativity studies. We first review standard computer-assisted composition environments, then style-modeling programs and finally interactive music systems.

2.5.1 Computer-based music composition

Many studies, if not all, in musical creativity have been based on the use of *standard* computer-based music composition systems. Although these tools are often referred to as “new technologies,” they usually denote standard computer programs such as sequencers or sound-effect processing systems, e.g. as described in Savage & Challis (2001). In the same vein, Folkestadt et al. (1998) describe in detail the process of music composition using a standard MIDI-based sequencer, and infer from these studies various composition strategies adopted by children in this context, such as vertical and horizontal composition strategies.

2.5.2 Computer music generation programs

The issue of building computer programs that generate music automatically has been dealt with since the very origins of computer science. Pearce et al. (2002) gives an account of this history and its debatable relation to musical creativity. Indeed, one can wonder to what extent computer music generation programs can be said to be creative or not, and Pearce gives several useful guidelines for such an endeavor, focusing in particular on evaluation issues. These studies show that the question of evaluating whether or not a given composition is creative *per se*, without referring to a specific context, seems to be a dead end. But if taking the context into account is recognized as crucial, there is no simple way to do so.

Here however, we are not dealing with the issue of how to make computers creative. We believe that the human composition process is, to our knowledge, still not understood well enough to attempt to model on computers, although we sketch in the next chapter (Pachet, 2004) some preliminary hypothesis and experiments in this line.

Neither are we interested in models of creativity *per se*, whose aim it is to explain how creativity works in humans considered as rational agents, as exemplified by Macedo & Cardoso (2001). Although such models may provide insights in creativity studies, they are usually based on abstract concepts (agents, speech acts) whose practical utility is debatable in our context.

We are on the contrary interested in man-machine interactions, and how creativity can stem from such interactions. By interaction, we mean the real-time relationship between a human user engaged in a musical activity and a program. Interactions are not both ways in our context, and we are strictly interested in 1) the objective output of the coupled user + system and 2) the psychological impact on the user. In particular, the creativity observed is to be assessed with regard to the normal activity of the user without the program.

In other words, we are not interested in creativity stemming from purely human activities, nor in creativity of software, but in creativity arising from *interactions* with machines. More precisely, we are interested in system design, i.e. how to design interactive systems which may provide such personal experiences. This point is particularly important as it differentiates our approach from most other approaches in computer music creativity.

2.5.3 Style modeling programs

Style modeling programs are one particular sort of computer music generation program, and because of their recent success, they deserve a special mention here.

There has been considerable research done in the fields of artificial intelligence and information theory regarding the technical issue of learning a musical style automatically in an agnostic manner. Shannon introduced the concept of information based on the probability of occurrence of events in communications (messages) in his seminal paper (Shannon, 1948). This notion was used soon after to model musical styles, one example being Brooks et al. (1957). These early experiments showed that it was possible to create pieces of music that would sound like given styles by simply computing and exploiting probabilities of note transitions. More precisely, given a corpus of musical material (typically musical scores or MIDI files), the basic idea was to analyze this corpus to compute transition probabilities between successive notes. New music can then be produced by generating notes using these inferred probability distributions. A good survey of state-of-the-art, Markov-based techniques for music can be found in Triviño-Rodriguez et al. (2001), including variable-length Markov models in particular, which capture stylistic information more finely.

One of the most spectacular applications of Markov chains for the generation of music is probably the Experiments in Musical Intelligence (EMI) system designed by David Cope (Cope, 1996; Cope, 2001), although his musical results are not entirely produced automatically. Although the use of Markov techniques is not explicitly mentioned, EMI is, like the other style modeling programs, based on a principle of analysis and recombination of musical elements (notes, patterns, etc.). These elements are extracted from a corpus of works, and annotated using high-level structural information. The extraction process is not always automatic and in any case not in real time (for technical details see (Cope 1996, 2001)). The system is mostly known for its spectacular productions of “music in the style of X.” Douglas Hofstadter, one of the greatest admires of Cope’s system, say the following about EMI:

> In twenty years of working in artificial intelligence, I have run across nothing more thought-provoking than David Cope's Experiments in Musical Intelligence. What is the essence of musical style, indeed of music itself? Can great new music emerge from the extraction and recombination of patterns in earlier music? Are the deepest of human emotions triggerable by computer patterns of notes?

It is important to note here that the initial motivation in the development of Cope’s EMI was not to perform style imitation, but rather to help the author explore his *own* musical style:

> When he created a computer program that composed music, David Cope didn't intend to cause an uproar; he was only looking for a new way to approach his own composing. But Cope's invention, Experiments in Musical Intelligence (EMI), sparked both amazement and outrage (one distressed musicologist went so far as to accuse Cope of having killed music as we know it). (Cope 2001)

This point has been somehow minimized with regard to the success of the fancy imitation games the system leads to. In our view, however, the interaction between Cope and his system, which is much less advertised, is the crucial point for several reasons. First, there are still a lot of processes in EMI which are not automatic and require manual input. Second, it is precisely the question of the exploration of a musical identity which is at stake here, and not so much the actual production of imitations. However, the interaction aspects of EMI have so far been hidden, and it is the purpose of our work to make this type of interaction explicit.

2.5.4 Music interaction Systems

Interactive music systems have been developed since the early days of computer music, and have blossomed in particular since the invention of the MIDI protocol, and in the early eighties with the MAX visual programming language. These standards and languages have made it possible to insert processing modules in the music perception-action loop, resulting in many new approaches to music performance. Rowe (1992) proposes a detailed analysis of the technical issues related to the design of interactive systems, and classifies interactive systems according to various dimensions. In particular he distinguishes between two main paradigms in interactive music systems. In the “instruments” paradigm, the goal is to construct an extended musical instrument. This approach is exemplified by the Hyperinstrument thread of research led by Tod Machover (Paradiso, 1999), in which the issues of intimate control and expressiveness is the key. Musically, the goal is to enhance expressiveness while allowing the musician to retain control. The musical results of the coupled user + machine are of the same nature as with traditional instruments: solos. The other paradigm is the “player” paradigm, in which the constructed system exhibits some musical personality. The musical outputs are thought of as duets between a human and a machine. This distinction is fundamental as it corresponds to two basic forms of music production (solo and duet). However, as proposed in (Pachet, 2004), we can think of another paradigms, which lie in the middle, i.e. duets with oneself, or extended solos.

Many pieces have been composed for interactive systems, leading to a substantial amount of technical work, described in particular by Rowe (2001). Jean-Claude Risset has also composed interactive pieces for MIDI piano (Risset and Van Duyne, 1996). In these pieces, preprogrammed, real time musical transformations are applied to musical sequences played on a MIDI piano. Each transformation defines the substrate of a piece. These transformations are applied to the local user input; for instance, each musical phrase is transposed and transformed into various arpeggios.

Interactive music has also produced interesting developments in the commercial field. Many synthesizers today offer sophisticated interactive modes, from basic one-touch chords to fully-fledged real-time orchestral accompaniments (e.g. the Yamaha PSR series). Although these developments have traditionally been despised by the scientific community, they do offer very interesting and innovative interaction modes, which are yet under-explored in creativity studies. For example, the interaction modes developed to trigger harmonic accompaniments using a limited set of keys (e.g. root + white key for major chord, root + black key for minor chords, etc.) have a notable impact on the playing modes of users which are still largely undefined.

Synthesizers in the professional domain are much more impressive and equally ignored by scientific studies. The Korg Karma workstation launched in 2000 offers an impressive range of new interaction modes, intimately integrated in state-of-the-art sound synthesis modules. The interaction modes are based on the notion of “musical effect” (Kay, 2000). An effect may be seen as a generalization of the notion of “transformation” as defined in interactive music research, to account both for user inputs and predefined music styles. An effect in this terminology is a way to integrate user input in a predefined musical style in a meaningful way. Effects can be very simple (arpeggiators) or very complex (generation of whole orchestral textures and ambiances from simple key strokes). The Karma workstation in its basic states offers about one thousand different settings, each one corresponding to a particular music ambiance, style, or mood. For each setting, about ten real-time control parameters are proposed, with varying semantics, including rhythmic density, syncopation, manner of arpeggiation, etc.

The only information we have concerning the use of such instruments comes from popular information channels. For example, the well known composer and singer Phil Collins declares in an interview (Collins, 2001) that he uses the Karma for composing.

Collins uses the Karma to write new material as well as to freshen up and expand grooves on already existing material. Commenting on a few of Karma's features, Collins says,

> Some of the grooves are fantastic. I can see using 8 or 16 bars and looping it. The tempo shifts make it a breeze compared to trying to recycle these old CD-ROMs. You get in there and try to split them up and then you find that you can't slow it up quite enough to keep the groove, so you have to go back and edit it again. I find the ease with which you can just shift the tempo with the Karma and actually get it to loop pretty invaluable for me, because my home studio is not really a place for live drums. Since the time of 'In The Air Tonight' onwards I've always been big on atmospheric loops, and some of these things just ooze all that atmosphere.

No study to our knowledge has been performed on such environments, but it would be extremely revealing to measure how long users remain interested in interactions using such preprogrammed effects, how they can actually boost creativity for both composition and real-time performance, and to what extent the comments by well known musicians are true and reproducible.

3 Conclusion

This chapter has introduced the notion of interactive systems as a theme for creativity studies. We described several approaches in interactive systems aiming at enhancing musical creativity, and conversely sketched some works in creativity studies that can be related to understanding creativity with interactive systems. This position is probably preliminary, as no systematic studies of creativity involving interactive systems has been conducted to our knowledge. Additionally, we stress on the fact that there has been many popular interactive music systems in use by the general public for more than a decade now, and that this situation creates a natural and rich area to study for those wishing to gain new insights in creativity.

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