Evaluating an improvising computer-implementation as a *partial creativity* in a music performance system

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Abstract. I analyse two specific cases of "improvising" music systems with the aim of developing some insights into what might constitute the "computational creativity" in each of these two implementations. First, I outline my working understandings of computational creativity and improvisation, giving a formal framework with which I subsequently examine my analyses of the two computer implementations: George E. Lewis's *Voyager* and my own *Favola*. I complement the formal framework with soft systems analysis in order to map the role of the implementations in the concert performance situations. Through this approach I evaluate each of these implementations as a *partial creativity* in the context of the "human activity system" of the performance situation.

Keywords: machine improvisation, computational creativity, partial creativity, analysis

1 Introduction

There is no definitive understanding of what "computational creativity" is, or might be, and so plenty of unanswered methodological questions appear when one attempts to evaluate the "creativity" of computational systems. For example: should computational creativity be compared to human creativity?[1] Arguably, this kind of comparison may be a category mistake.[2]

The present research develops an approach for evaluation of two specific cases of "creative" computational music systems by invoking a formalist framework

[1] This was a contentious topic in the recent CSMC16 conference. See some discussion of this in my conference review (Mogensen, 2017).

[2] One reason that the comparison may be a category mistake is this: given current computer technology, "[p]erhaps no *non*living system will exactly model human mental functions... [these functions] are closely connected with our needs and interests as *living* systems... [and so] play a large role in keeping us alive and well". However, "[n]onliving systems obviously do not share that need to maintain life and well-being" (Cunningham, 2000, pp. 219). In other words, if human creativity is at least partly determined by self-generated motivations, then it would seem that a (nonliving) computational creativity, incapable of self-generated motivations, would necessarily be another logical category.

which is complemented by soft systems analysis of the performance context. This framework does not necessitate comparison between human and computational creativity and it does allow for human and computational systems to be *co-creative* in improvised music performances.

I first outline a working understanding of computational creativity, with which I subsequently analyse two implementations: 1. George E. Lewis's *Voyager* from 1987 and 2. my "improvising computer accompanist" entitled *Favola* from 2015. With this approach I attempt to evaluate the "creativity" of these in the context of the "human activity system"[3] of the performance situation. From these analyses I develop the idea of a *partial creativity*; by this term I mean that any creativity in the computational implementation is emergent through its position in a human activity system. In other words, the implementation is necessary, but not sufficient for the creative output of the music performance situation and the performance situation is necessary for the emergence of the partial creativity of the implementation.

I have previously described my implementation of "an experimental improvising computer accompanist, which I named *Favola* and which is based on a creative transformation of my analytical view of George E. Lewis's *Voyager* (1987) system" (Mogensen, 2016a, p. 1).[4] In the previous work I attempted "to invoke a semiotic basis for evaluation of the resulting music" (Mogensen, 2016a, p. 2). In the present article I re-examine the analysis of Lewis's *Voyager* (Mogensen, 2016a, pp. 2–4), in section 4. In section 5 I expand the analytical view of his work with soft systems analysis, placing *Voyager* in the "human activity system" of the performance situation. Previously, I argued that the "question of evaluating *Favola* as a convincing part of the human activity system, in terms of how it contributes to the musical experience, becomes a question of how convincingly it fulfills the roles of Rowe's player- and instrumental paradigms" (Mogensen, 2016a, p. 8).[5] However, in section 5, given my working understanding of "creativity", I return to the analytical perspective that *Favola* is part of a human activity system, in an attempt to argue for a *partial creativity* in the music performance situation particular to this work.

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[3] "Human activity system" is an expression borrowed from soft systems analysis as used by Wilson (2001, pp. 9–10).

[4] I made a speculative high-level mapping of components and functionalities in George E. Lewis's *Voyager* according to published information about the work (Lewis, 2000). Transformations of this analysis resulted in an algorithm that I could implement in an interactive improvising computer accompanist, which I call *Favola* (Mogensen, 2016a).

[5] Robert Rowe (1993) proposed a taxonomy which polarised what he called the "instrumental paradigm" and the "player paradigm" in interactive music works. The "instrumental paradigm" aspect is present when the computer-parts of the works can be heard as extending the sounds of the performed acoustic instruments. In Rowe's "player paradigm" the computer exhibits independence as "an artificial player, a musical presence with a personality and behavior of its own, though it may vary in the degree in which it follows the lead of the human player" (p. 8).

Regarding *Voyager*, Lewis argued for the concept of "an automatic composing program that generates complex responses to the musician's playing" (2016), and I take this to be an *improvising* computational system. *Favola* is specifically constructed to improvise pitch structures using additive synthesis, and so I argue that its potential creativity would also be considered as improvisation albeit with a limited palette of sounds. As an accompanist *Favola* is intended to function as a co-improviser, and this may be examined as *co-creativity* (Kantosalo & Toivonen, 2016) which resonates with the soft systems analysis approach; this allows a view of the entire performance system as being "creative", as is discussed in section 6. In section 7, given the idea of co-creativity, I return to the semiotic and musicological approaches from the previous analysis (Mogensen, 2016a, pp. 6–8) and briefly examine the intertextual situation of *Favola* in light of the idea of *partial creativity* in a machine improviser.

2 A working understanding of "computational creativity"

To outline a working understanding of "computational creativity" for the present context, I adapt and modify Geraint A. Wiggins's (2006) "preliminary framework for description, analysis and comparison of creative systems" (p. 449). The idea of "creativity" was formalised by Wiggins as explorations in, and transformations of, "conceptual spaces". Wiggins formalised his interpretation of the ideas of Margaret Boden (2004) who proposed that "conceptual spaces are structured styles of thought" (p.4). To support the analyses of *Voyager* and *Favola* an overview of the relevant parts of Wiggins's formalisation is proposed in Z-style schema notation[6]: I summarise Wiggins's (2006) Axioms (pp. 451–452) in Figure 1 and his approach to determining 'creative output' (pp. 452–453) in Figure 2. In Wiggins's formalism "creativity" is seen as searches in a conceptual space ($\mathscr{C}$), which is a subset of the universe of possible concepts ($\mathscr{U}$).[7] Wiggins (2006) described two levels of creativity within his formal system as: 1. "exploratory creativity" and 2. "transformational creativity" (pp. 453–454). Given this framework I will examine the implementations of *Voyager* and *Favola* with emphasis on "exploratory creativity".

[6] Briefly, the Z schema notation includes a declarations part above the central horizontal line and predicates below the horizontal line. In Figure 1 the declarations are interpreted as follows: $\mathscr{C}$ is a concept space of type Σ in the universe of possible concepts $\mathscr{U}$. C is a concept type and c^1, c^2 are instances of C and $\top$ is the empty concept, all of which may be within a concept space $\mathscr{C}$. "The central horizontal line can be read 'such that'." The axiomatic predicates (below the line in Figure 1) "appearing on separate lines are assumed to be conjoined together, that is to say, linked with the truth-functional connective $\wedge$" (Diller, 1990, 6). "The Z language is both a formal language and a specification language" (Diller, 1990, 3). I am not providing complete Z specifications here, but have found the notation style convenient for presenting the argument in this article.

[7] For a full narrative explanation of more details of Wiggins's model I refer the reader to his 2006 paper.

$$
\begin{array}{|l}
\mathscr{U} : \textit{Possible concepts} \\
\Sigma : \textit{Concept space type} \\
C : \textit{Concept type} \\
\mathscr{C} : \textit{Instance of } \Sigma \\
\top : \textit{Empty concept} \\
c1, c2 : \textit{Instances of } C \\
\hline
\top \in \mathscr{U} \\
\forall\, c1, c2 \in \mathscr{U} | c1 \neq c2 \\
\forall \mathscr{C} | \mathscr{C} \subseteq \mathscr{U} \\
\forall \mathscr{C} | \top \in \mathscr{C}
\end{array}
$$

Figure 1 – My summary of Wiggins's four Axioms.

Wiggins proposed an approach to evaluating concepts, discovered through the searches, which is summarised in Figure 2: a *Language* ($\mathscr{L}$) gives the basis for a *Search strategy* ($\mathscr{T}$) and *Constraints* ($\mathscr{R}$) on the conceptual space ($\mathscr{C}$), along with *Evaluation criteria* ($\mathscr{E}$), that are related to form part of the input to a decision function which consists of an *interpreter* $\langle\langle ., ., . \rangle\rangle$ and an *evaluator* $[[.]]$. To this model I have added *Motivated activity* ($\mathscr{M}$) as a "motor" to drive the generation of output over time (t). I am using this model in the special case of musical improvisation and so the conceptual space, or "structured style of thought" in Boden's words, does not necessarily consist of abstract concepts. Rather, I argue, the search space consists of sounds, which might be conceptualised, but which are physical phenomena. Sounds by necessity have a time dimension, and therefore some driver through time is necessary, for the search and evaluation function to be applicable in this special case of creative systems. I will outline a working understanding of "improvisation" in section 3.

3 A working understanding of "improvisation" as creativity

Lewis (2000) argued that his *Voyager* system "is a nonhierarchical, interactive musical environment that privileges improvisation" (p. 33). I argue that as an expert improviser, Lewis has encoded his own analytical view of improvisation in the software for *Voyager*. Furthermore, any "creativity" which may be emergent in *Favola*, during the performance context, is specifically expressed through "improvisation" and so a working understanding of improvisation for the present discussion will help to ground the argumentation.

Hazel Smith and Roger Dean (1997) suggested that "[t]he idea of improvisation [by human performers] is related to that of creativity as working process... includ[ing] that of *finding* the art work by an explorative process rather than working towards a pre-conceived goal" (p. 33). Aaron L. Berkowitz (2010) used a definition of "improvisation" as "spontaneous creativity within restraints" (p.

Creative Output

$\mathscr{L}$: *Language*
$\mathscr{R}$: *Constraints on concept space*
$\mathscr{T}$: *Search strategy*
$\mathscr{E}$: *Value definition*
$\mathscr{M}$: *Motivated activity*
t : *Time*
$\langle\langle .,.,. \rangle\rangle$: *Wiggins's interpreter function*
$[[.]]$: *Wiggins's evaluator function*

$\mathscr{R}, \mathscr{T}, \mathscr{E} \in \mathscr{L}$
$[[\mathscr{E}]]\Big(\langle\langle \mathscr{R}, \mathscr{T}, \mathscr{E} \rangle\rangle \big(\mathscr{M}(t)\big)\Big)$

Figure 2 – My adaptation of Wiggins's "[e]valuating members of the conceptual space".

1). These concepts of "improvisation" both resonate very well with the working understanding of computational creativity from section 2: Wiggins's expression of *explorations* of conceptual spaces seems analogous to Smith's and Dean's "explorative process", and Berkowitz's "restraints" can be exemplified by Wiggins's constraints ($\mathscr{R}$) on concept spaces.

Smith and Dean (1997) furthermore proposed that "[i]n its purest form an improvisation involves the simultaneous conception and performance of a work of art" (p.26). They sought "to connect the process of creativity in improvisation with the work created and its reception: and to emphasise exactly the process-product interchanges" (p. 29).

I argue that, as members of a concept family[8] of improvisational "creativity", the computer systems in *Voyager* and *Favola* are co-creative with human performers; the co-creativity is dependent on the creativity of the human performers, but the music resulting from the system is emergent from the co-creativity of the hybrid human-computer situation; the activities of the human performers on their own would be insufficient to generate the same results.

4 Speculative analysis of Lewis's *Voyager* system

Based on recordings[9] and Lewis's published description I made a speculative analysis of the software functionality in *Voyager* (Mogensen, 2016a), which is

[8] Different parts of what we call "creativity" may "share what Wittgenstein called 'family resemblances' " and so the concept family name "creativity" can be understood "as a family name for a series of capacities that have some overlapping similarities as well as some significant differences" (Cunningham, 2000, p. 67).

[9] A series of recordings are available on the internet, in which Lewis (trombone) and/or Roscoe Mitchell (saxophone) improvise with the system (Lewis, 2016).

summarised with minor adaptations in Figures 3 and 4. The analysis of *Voyager* is understood as follows[10]: I represent Lewis's 64 "players" as $A[1..64]$ and the system assigns these players into Lewis's "behavioural groups" which I call $B[1..n]$. I indicate n behavioural groups since Lewis does not state how many there are. The assignments of players $A[1..64]$ into behavioural groups $B[1..n]$ are made dynamically by the software, recalculated at time t every 5 to 7 seconds, according to a parameter derived from analysis of pitch input (from the musician), and this parameter (at time t) is represented as $M(t)$.[11] As a result, any one particular group $B(s, t)$, where $1 \leqslant s \leqslant n$ at time t, may be calculated as the set of functions f_s with inputs from the players $A(p, t)$ and pitch analysis $M(t)$ at time t. Lewis (2000) mentioned that the system chooses among "15 melody algorithms", "150 microtonally specified pitchsets", and a number of MIDI parameter ranges, and assigns these choices to the "behavioural groups" (p. 35). I represent these choices as $K(t)$, $P(t)$ and $L(t)$.

Voyager Behaviour Group

A : *Voyager player*
K : *Melody algorithm*
P : *Pitch set*
L : *Parameter ranges*
M : *Analysis musician input*
R : *Random generator*
f : *Lewis's assignment function*
t : *Clock time*

$$B(t) = \bigcup_{p=1}^{64} f\Big(A_p(t), C(t), K(t), P(t), L(t), R_p(t), B(t-1)\Big)$$

Figure 3 – My summary of a *Voyager* Behaviour Group.

It seems likely that some randomising parameter, perhaps with individual weightings for each player, would occur in *Voyager*, and so I represent this random element $R(p, t)$ for each player $A(p)$ which might be applied within any or all f_s functions, with recalculations at each time t. It also seems likely that Lewis's algorithm will take into account what has just been played, in order to determine what the next activity is to be for the electronic part, and so finally I

[10] With a few minor modifications, this analysis is equivalent to the one I have previously described (Mogensen, 2016a), but here I use schema notation since this facilitates a concise exposition of the relation to the formal model of computational creativity from section 2.

[11] Previously (e.g., Mogensen, 2016a), I used C instead of M which might lead to confusion in the context of Wiggin's formalisation; I also summed the results of the Behaviour Groups, but for the present analysis the union of Behaviour Groups is more appropriate.

Voyager Orchestra

B : *Voyager Behaviour Group*
O : *Sound(MIDI) output*
t : *Clock time*
n : *Number of Behaviour Groups*

$$O = \bigcup_{s=1}^{n} \Big(B_s(t) \Big)$$

Figure 4 – My summary of *Voyager*'s Orchestra.

include $B(s, t-1)$ as an additional input into f_s. This analysis gives the schema in Figure 3 for each individual Behaviour Group s at time t, and the resulting "improvised action" to be implemented by the Electronic Orchestra at time t is then represented by the set of the behavioural groups as shown in Figure 4, which is recalculated every 5 to 7 seconds.

If we interpret *Voyager* as a kind of exploratory search engine in a musical space then it will make sense to relate my interpretation of the *Voyager* system to the formalisation in Figure 2. This relation is summarised in Figure 5 with four explanatory details as follows:

1. The language ($\mathscr{L}$) is the Forth Music Language (FORMULA), which Lewis (2000) used to code the *Voyager* system (p. 35).

2. The constraints on the concept space ($\mathscr{R}$) are defined by: $\big($MIDI instruments (EMU Proteus/2), $K, P, L\big)$.

3. The search strategy ($\mathscr{T}$) is contained in: (f, R, A)

4. The value definition ($\mathscr{E}$) is summarised by Lewis's statement that *Voyager* "is a nonhierarchical, interactive musical environment that privileges improvisation" *(NHIE)*. While this expression is in English, which is not part of $\mathscr{L}$, I presume that Lewis has encoded his stated priorities into the *Voyager* system.

The analysis of the musician's playing could arguably enter into $\mathscr{E}$ as well, since reactions by the musician to sounds output by the computer, can be interpreted as musical "valuation" of that computer output; Lewis's approach to interpretation of the musician's musical actions is encoded in the *Voyager* system. Wiggins's exploratory function can then be expressed in more detail[12] for the specific case of *Voyager* as shown in Figure 6.

The creation of *Voyager* by Lewis could be considered to be an example of "transformational creativity" since the expression, or "structured style of thought", which *Voyager* encodes was new at the time (1987) and could be said to have transformed the $\mathscr{C}$ of improvising computer-implementations at the time. However, it would seem that the improvisational output of *Voyager* is exploratory within the conceptual space created by Lewis in this system. Alternatively, was the *first* performance with *Voyager* transformational, since it was a new style of improvisation?

[12] Where "nonhierarchical improvisation environment" is abbreviated as *NHIE.*

Voyager Creative Output

$\mathscr{L}$: *Language* = *Forth Music Language code*
$\mathscr{R}$: *Constraints on concept space* = (*MIDI instruments*, K, P, L)
$\mathscr{T}$: *Search strategy* = (f, R, A)
$\mathscr{E}$: *Value definition* = *nonhierarchical improvisation environment* (*NHIE*)
$\mathscr{M}$: *Motivated activity* = (A, M)
t : *Time*
$\langle\langle .,.,. \rangle\rangle$: *Wiggins's interpreter function*
$[[.]]$: *Wiggins's evaluator function*

$\mathscr{R}, \mathscr{T}, \mathscr{E} \in \mathscr{L}$
$[[\mathscr{E}]]\Big(\langle\langle \mathscr{R}, \mathscr{T}, \mathscr{E} \rangle\rangle \Big(\mathscr{M}(t)\Big)\Big)$

Figure 5 – Putting my *Voyager* analysis into the schema *Creative Output* (Figure 2).

$$\mathit{Voyager\ Creative\ Output} = $$
$$[[\mathit{NHIE}]]\Big(\langle\langle(\text{MIDI instruments}, K, P, L), (f, R, A), (\mathit{NHIE})\rangle\rangle\Big(A, M(t)\Big)\Big)$$

Figure 6 – Putting my *Voyager* analysis into the creative output function from Figure 2.

Arguably, each performance by *Voyager* is new, in the sense that it never repeats itself precisely. But is each performance "valued" as a creative performance, where *Voyager* fulfils Boden's (2004) definition of creativity, and has "the ability to come up with ideas or artefacts that are *new, surprising and valuable*" (p. 1)? Boden (2004) furthermore argues for a graduated scale of "how creative" something is and for asking in "just which ways" is something creative (p. 2)? However, I argue that within the present working understanding of improvisation as creativity, the *partial creativities* examined here are not more or less creative, instead they form necessary parts of a human activity system, where the system as a whole has emergent creativity. With this view the implementations are creative in "the ways" in which they function in the performance system.

If we accept improvisation as being creative, at least potentially, then in the general case this will tend towards what Gilbert Ryle (1976) argued[13]:

> What comes to pass on one occasion has, with all its concomitants, origins, and details, never taken place before and will never take place again. It may be and usually is completely unremarkable; as unsurprising when it happens as it had been unanticipated before it happened. The world and what occurs in it are, with a few exceptions, neither like chaos nor yet like clockwork... It follows that the things that we say and

[13] Berkowitz (2010) pointed out most of this passage in discussing music improvisation (p. 181).

> do in trying to exploit, avoid or remedy that small minority of the particular partly chance concatenations that happen to concern us cannot be completely pre-arranged. To a partly novel situation the response is necessarily partly novel, else it is not a response. (p. 73)

So Ryle can be interpreted as arguing that all human activity is improvised and all improvisation is *new*. Perhaps Boden's "value" of the *new*, in the special case of music, is socially determined and so is entangled with the human activity system which can be named "culture". At the scale of "culture", creativity can then be modelled as nodes in the cultural inter-text.[14] I return to this idea in section 7.

5 Soft systems analysis of Lewis's *Voyager*

I interpreted the performance of *Voyager* as a "human activity system" and I adapted the method of *Soft Systems Analysis* as discussed by Checkland (1981), Flood and Carson (1993) and Wilson (2001).[15] Soft systems analysis is an approach that calls for diagrammatic visual mapping of the elements and the connections between elements of a system.[16] Flood and Carson (1993) distinguished between "structural" and "behavioural" modelling approaches to system identification (p. 71). When applying Flood's and Carson's view to the music performance situation, a basic premise would be that there exists a collection of physical and conceptual elements necessary for a performance of a musical work to exist, which we can identify following a structural modelling approach. This necessary collection of elements will vary from work to work, according to instruments and equipment needed, musicians and technicians required, and the physical media which carry the information about the composition.

Soft systems diagrams show the "objects" and the routes which "influences" can take between these objects (Flood & Carson, 1993). I applied this concept in my soft system diagram of the performance situation of Lewis's *Voyager* as shown in Figure 7, based on published information from Lewis.[17] In this diagram physical and conceptual "objects" are named within rectangles, persons

[14] See Allen (2011) for a discussion of the concept of the cultural "inter-text".

[15] Other examples of soft systems analysis of the performance situation of music works include an article by Mogensen, Deletaille, and Roudier (2014) and parts of my dissertation (Mogensen, 2016b).

[16] Soft systems analysis has mainly been developed for applications in economics, business studies and other social system modelling. Some adaptations of the method are necessary: the CATWOE test of "Root Definitions" (Wilson, 2001, pp. 24-28) had to be redefined for the current research in music performance systems. These systems have sets of purposes and structures that differ from those of most business or sociological systems models. In a larger cultural context, the CATWOE test may be applicable to modelling music works, but the current research is at a low-level "resolution" where the involved processes of the system are taken to be essentially self-contained, and the basic purpose of the system is taken as a given: to realise an improvisation in a performance space.

[17] See Lewis's (2000) article, and (2016) web-site.

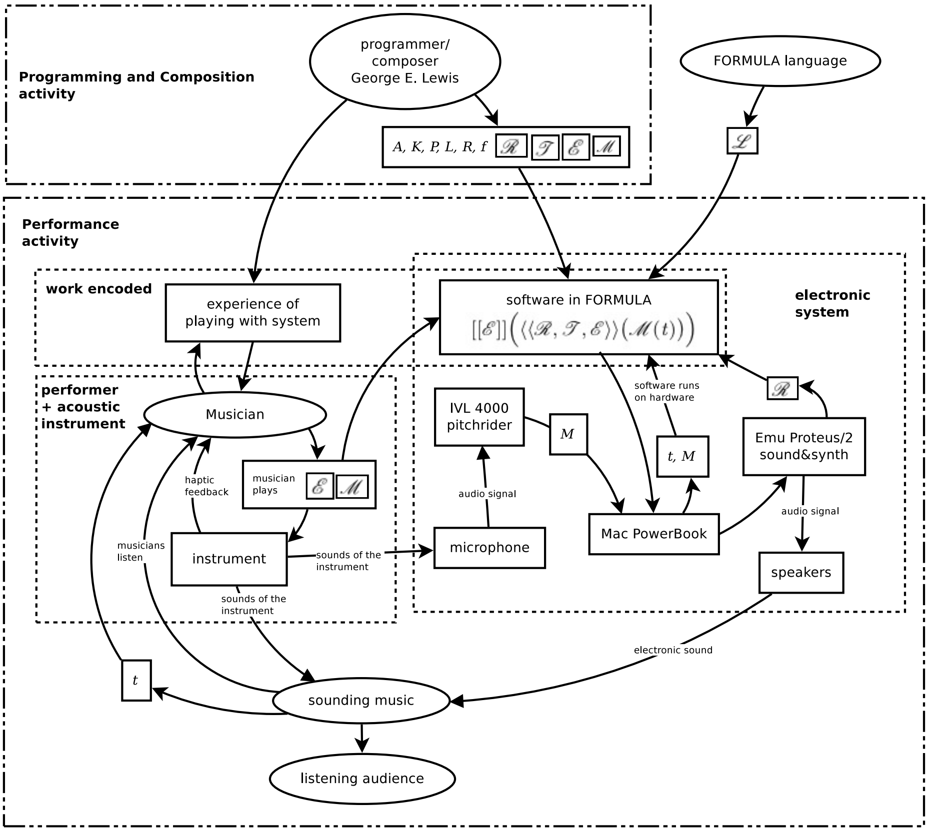

Figure 7 – My soft system analysis of Lewis's *Voyager* as played by Lewis.

within ovals and arrows indicate what I interpret to be directions of "influences" between these objects, all within the performance situation of the work.

I place the components from Figure 5 in the soft system diagram and use this to illustrate an interpretation of the "partial creativity" aspect of *Voyager*. I argue that both $\mathscr{E}$ and $\mathscr{M}$ are at least partially determined by the musician performance through the transmission of M; in effect the musician activity both motivates and restricts the computational search by his improvised choices: this is indicated in Figure 7 as the arrow from the "performer" segment to the "work encoded" segment. I argue that a similar contribution of motivations and restrictions might be transmitted from the output of the computer system to the improvised activities of the musician, via the musician listening to and being sensitive to the sounding music in the performance space; in short, such exchange is "interaction" between the musician and computer system in the musical context.

This idea of interaction between musician and computer system is analogous to interaction between two musicians in a group performance: using examples from jazz music and improvised theater, R. Keith Sawyer (2006) argued that "the key characteristics of group creativity are improvisation, collaboration, and emergence" (p. 153). Sawyer (2006) used the term "group flow" to indicate an "emergent property of the [performing] group... [which] can inspire musicians to play things that they would not have been able to play alone, or that they would not have thought of without the inspiration of the group" (p. 158). Group flow "depends on interaction among performers and it emerges from this process" (p. 159). In the context of *Voyager* I speculate that there is the possibility of "group flow" between the musician and the computer system and hence the possibility of human-computer "group creativity".

6 *Favola*: a partial creativity in a co-creative context

As I have discussed previously (Mogensen, 2016a, pp. 4–5) I used a creative transformation of my analysis of *Voyager* as a basis for the new improvising computer accompanist *Favola*.[18] The details of my creative transformation are not essential for the present line of argument, instead I summarise my *Favola* algorithm in Figure 9: briefly, I used a six agent *boids* flocking algorithm[19] that motivate pitch and spatialisation of six note-structures played via additive synthesis. The analyses of the pitch classes played by the musician are also used as input to transform the synthesis parameters.

In a similar way to the analysis of *Voyager*, in section 4, I can interpret *Favola* as an exploratory search engine in a musical space and as such it will be useful to place the components of the system into the formal model from section 2. Figure 8 relates my interpretation of the *Favola* system to the formalisation from Figure 2, with four explanatory details as follows:

[18] I have revised the expression of my analysis here to accommodate the schema notation and the line of argument of the present article.

[19] I used a "boids"-like algorithm in Javascript within MaxMSP, based on *Boids* of Craig Reynolds (1987).

1. Constraints on concept space ($\mathscr{R}$) are defined by: (*Additive Synthesis*, *L*)
2. Search strategy ($\mathscr{T}$) is contained in: (f, Q)
3. Value definition ($\mathscr{E}$) is summarised by: *Improvising Accompanist (IA)*
4. The *Favola Creative Output* can then be expressed for *Favola* as shown in Figure 10.

Favola Creative Output

$\mathscr{L}$: *Language* = *MaxMSP and JavaScript*
$\mathscr{R}$: *Constraints on concept space* = (*Additive Synthesis*, L)
$\mathscr{T}$: *Search strategy* = (f, Q)
$\mathscr{E}$: *Value definition* = *Improvising Accompanist* (*IA*)
$\mathscr{M}$: *Motivated activity* = (Q, D, G)
t : *Time*
$\langle\langle .,.,. \rangle\rangle$: *Wiggins's interpreter function*
$[[.]]$: *Wiggins's evaluator function*

$\mathscr{R}, \mathscr{T}, \mathscr{E} \in \mathscr{L}$

$$[[\mathscr{E}]]\Big(\langle\langle \mathscr{R}, \mathscr{T}, \mathscr{E} \rangle\rangle \Big(\mathscr{M}(t)\Big)\Big)$$

Figure 8 – Putting my *Favola* analysis into the schema *Creative Output* from Figure 2.

Previously (e.g., Mogensen, 2016a), I argued that "the proposition that *Favola* has the role of computer *accompanist* implies that the improvisational language of the human performer is defining for the overall character of the improvised music in a specific performance". So, "[i]n other words, the evaluation of *Favola*'s output is only possible in the context of specific performances that includes human improvisers" (Mogensen, 2016a, pp. 7–8). Within the interactive system, as mapped in the soft systems analysis in Figure 11, "*Favola* has a dual aspect: firstly, as a 'player' producing, in musical terms, an independent voice in the musical performance which can be called 'accompaniment' to the human improviser; secondly, as an 'extension' of the human instrumental performance"[20] (Mogensen, 2016a, pp. 7–8). This supports the argument that *Favola* is not "creative" in the human sense, but can be understood as a *partial creativity* which functions within a *co-creative role* in conjunction with a musician in the performance system.

The output of the *Voyager Orchestra* (Figure 4) tends to sound substantially more complex in rhythmic and orchestrational terms than the output of the *Favola Orchestra* (Figure 9). Lewis maintained that *Voyager* would generate output even without human performer input and so could function as a solo

[20] This reverberates with the ideas of Robert Rowe's (1993) taxonomy which polarised what he called the "instrumental paradigm" and the "player paradigm" in interactive music works.

$$
\begin{array}{|l}
\hline
\textit{Favola Orchestra} \\
L : \textit{Parameter range limits} \\
D : \textit{Pitch class analysis of musician input} \\
G : \textit{Envelope follower of musician input} \\
Q : \textit{Boids swarm agent positions in } 2D \textit{ polar coordinates } (Distance, Azimuth) \\
N : \textit{Foot pedal signal} \\
f : \textit{MIDIpitch calculation} \\
t : \textit{Clock time} \\
S : \textit{Synthesis pitch structure} \\
O : \textit{Output onset and envelope} \\
\hline
f : \Big(\Big(D \cdot Q(Distance) \cdot 12 \Big) + \Big(Q(Azimuth) \cdot 8 \Big) + 36 \Big) \\
S(t) = \bigcup_{n=1}^{6} f \Big(Q_n(t), D(t), L \Big) \\
O : \Big(G(t) > threshold \Big) \cdot S(t) \\
\hline
\end{array}
$$

Figure 9 – My summary of the *Favola* system.

$$
\begin{aligned}
&\textit{Favola Creative Output} = \\
&[[IA]]\Big(\langle\langle (Additive\ Synthesis, L), (f, Q), (IA) \rangle\rangle \Big(Q(t), D(t), G(t) \Big) \Big)
\end{aligned}
$$

Figure 10 – Putting my *Favola* analysis into the creative output function from Figure 2.

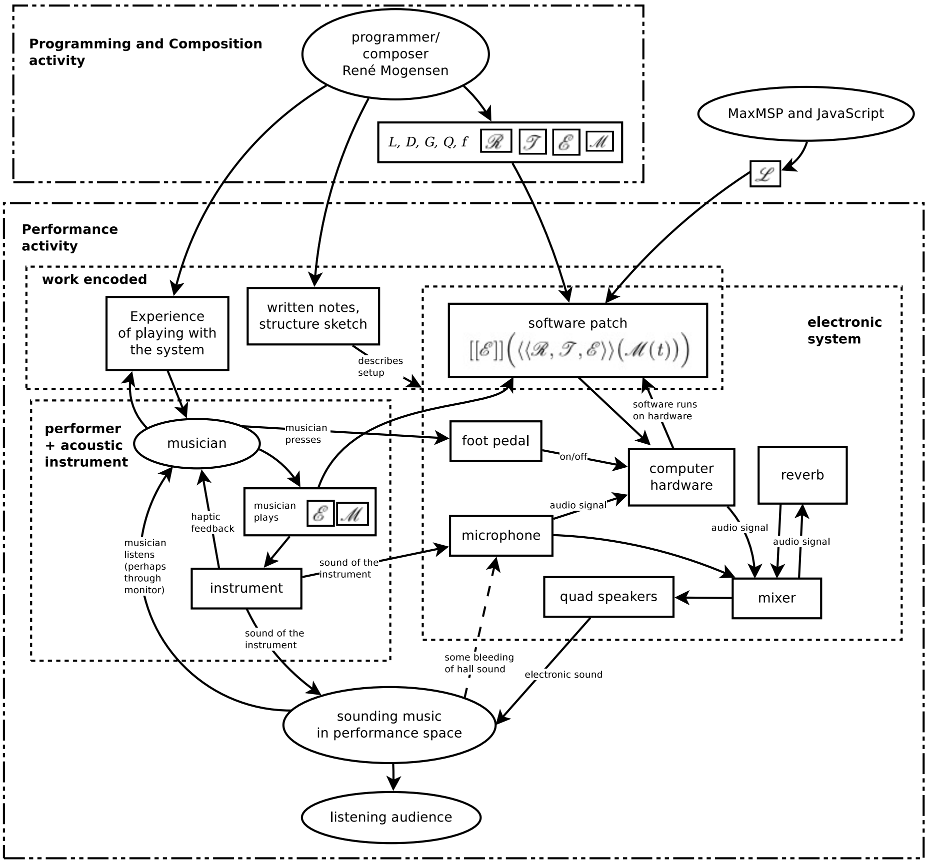

Figure 11 – Soft system diagram of *Favola*, indicating components and connections.

improviser, and this might also be a result of the greater potential complexity of its output. While complexity is not necessarily an indicator of creativity, one might ask whether the higher level of complexity might imply that *Voyager* is a more *complete* creativity than the *partial* creativity of *Favola*?

However, to try to quantify something as more or less creative in this context may be a mistake. The term *partial*, as I use it in this relation, refers to the aspect that the computational creativity is insufficient by itself for the creative output to emerge; so the computational creativity is dependent on being active within the human activity system in order for the system creativity to emerge. To evaluate whether the solo output of *Voyager* can qualify it as a (non-partial) creativity will demand further analysis of specific instances of the generated music, which is beyond the present scope.

7 Conclusion

Peter Gärdanfors (2000) proposed geometric representation of "conceptual spaces" as complementary to the symbolic and associationist methodologies that "attack cognitive problems on different levels"[21] (p. 1). This implies the possibility of *partial creativity* in computational systems. It may be that there is no single process that can represent "creativity", whether in humans or elsewhere. Instead "creativity" may be an example of one of Wittgenstein's concept families, and thus cover "a series of capacities that have some overlapping similarities as well as some significant differences" (Cunningham, 2000, p. 67).

It should be pointed out that my addition of $\mathscr{M}$: *Motivated activity* to Wiggins's formal framework is significant, at least in the special case of a machine improviser. Wiggins's model does not seem to make explicit what will motivate explorative creativity: why would the system enter input into the *interpreter* and *evaluation* functions of *Creative Output* (from Figure 2) without any motivation to do so? The implicit reason is that the human programmer has told the system to do so, in effect the motivation exists as imperatives built into the system. I hypothesise that other possible approaches to "motivation" may support other "computational creativities" and this is a topic that demands further work. In the cases of *Voyager* and *Favola* part of the motivation $\mathscr{M}$ comes from the imperatives of the programming and part from the musical improvisations of the performing musicians as discussed in sections 5 and 6.

As mentioned in footnote no. 2, self-generated motivation may indicate a category difference between human creativity and computational creativity. If there is such a category difference then, in the case of the partial creativity within a human activity system, it may be that the self-generated motivation *necessarily* resides in the human performers, and cannot sufficiently reside within the computational system (the computer-implementation). On the other hand, motivation may be a purely human function, which may not be necessary for computational creativity, and by introducing it into the model of computational

[21] This was also discussed briefly in my review of CSMC16 (Mogensen, 2017).

creativity I may be entangling two different types of "creativities": more work is needed to resolve this.

My use of *partial creativity* indicates a computational "creativity" that may, or may not, emerge within a human activity system. The system as a whole may have emergent creativity, but this creativity indicates a family of necessary capacities which, however, are individually insufficient for emergence: in the special case of improvised music, creativity may emerge as "group flow" which is dependent on individual activities of group participants, whether these participants are musicians or computer-implementations such as *Voyager* or *Favola*.

The algorithm of *Favola* is examined as a model which simulates creative musical accompaniment and there is no implication of any presence of human-like cognitive process in *Favola*. With *Favola* I have encoded a limited analytical view of improvised accompaniment, as a transformation of Lewis's encoding of improvisation in *Voyager*. I argued that "[t]he effectiveness of the improvising computer accompanist is largely dependent on the character of the music improvised by the human performer". (Mogensen, 2016a, p. 8) However, with some analysis of test performances I also found that "the algorithm derived from my transformed analysis of Lewis's *Voyager* can have an engaging musical effect in an improvisation context". (Mogensen, 2016a, p. 8)

As a necessary part of a system that performs engaging music, *Favola*, along with it's performance context, can be understood as an intertextual node in the network of a larger cultural inter-text.[22] This node is then informed by my encoding of the generative structure in Figure 9. Furthermore, it is informed by Lewis's *Voyager*, through my transformation of analysis (from Figures 3 and 4) which gives the basis for the implementation of *Favola*.

If one expands the human activity system view to a cultural scale, where musical culture is an intertextual network, one might argue that a performance which includes *Favola*, as a node in that network, is a partial creativity in the ongoing "creative" morphology of the inter-text. This view would take creativity and partial creativity as emergent properties at the societal-cultural level, rather than at the level of an individual computational agent or human being. Given this view, I speculate that Boden's "historical creativity" ("H-creativity") may best be understood at the societal level as something emergent from the intertextual network. Boden's "psychological creativity" ("P-creativity") may then be considered as partial creativities at the societal level.[23] But such scaling of the 'partial creativity' idea will have consequences that are beyond the scope of the present article, so it will remain a subject for future work.

[22] See Allen (2011) for discussion of "intertextuality" and "inter-text".

[23] Boden's (2004) P-creativity, "[t]he psychological sense [of creativity] concerns ideas... that are fundamentally novel with respect to *the individual mind* which had the idea", whereas "the historical sense [H-creativity] applies to ideas that are fundamentally novel with respect to *the whole of human history*" (p. 43).

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