CREATIVE STRUCTURES OR STRUCTURED CREATIVITY
Examining algorithmic composition as a pedagogical tool

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ABSTRACT
This empirical study aims to depict how composers develop and structure creative resources, aided by algorithmic methods and other means of structuring material and processes. The project is not meant to be conclusive, but rather to form a point of departure and raise questions for further theoretical and empirical study in the field. Implications for teaching and learning composition and for designing interactive musical tools are expected.

In specific, this paper concerns concept development within learning of music composition: if, how and to what extent this is comparable to that of language-based learning. The research project in progress sets out to study cognitive processes of composers working to integrate the outcome of composition algorithms, with the subjective compositional aim and modus operandi. However, in most cases the composer is also designer of the algorithm or at least of its specific application to the compositional problem. Consequently the strategies involved in designing and applying compositional algorithms need to be considered and discussed insofar that they too are part of the integration process.

The study at hand draws from research conducted in cultural-historical psychology, cognitive psychology and linguistic theory, concerning internalization, development of concepts and syntactic and semantic aspects of musical structures.

1. INTRODUCTION
The first section of this paper aims to sketch a setting and a point of departure for the research project. Section two contains a brief discussion of theoretical and methodological considerations. Section three discusses algorithmic methods and reasons for applying them. The fourth section holds a description of the empirical studies. Then follows a presentation of the results in section five and a summary of these in section six and lastly there is a discussion of the results and implications for further study in section seven.

This paper is part of a larger study in music pedagogy, examining different aspects of learning composition, on the axis of concept development and meaning making. Though the project is pedagogical, the problems that inhabit it wander off into the realms of cognitive psychology and semiology. In composition tuition a fundamental problem area is what could be described as a dichotomy between techniques and creativity. In pedagogical praxis there are countless methods and systems for developing technical compositional skills, but few devoted to elaboration of creativity development in itself. One point of argument is that tools and systems are conceptualizations of musical thinking and that creative development is implicit as an effect of their application. Outside the pedagogical literature, there is a vast tradition that branches into several fields of research and artistic practice, working to formalize and mimic creative activity, David Cope (2000) has used statistic analysis to pinpoint traits of musical styles of various composers and to have computer programs compose within those styles, and John Sloboda (1985) has studied creative processes of composition and even used his own composing as an object for study, just to mention a few. Questions of meaning-making and discourses in semiology supply substantial contributions to the field of music philosophy. In focus for this study will be creativity, musical concept development and meaning-making in the context of learning composition.

2. THEORETICAL CONSIDERATIONS
This is a qualitative empirical study employing observations and interviews for data collection. The following section gives an account for fundamental theoretical considerations and makes reference to earlier research.

The study takes its theoretical point of departure in cultural-historic perspective with special respect to Vygotskij and his theories about the forming and development of concepts. In addition, findings in cognitive psychology research, Chomsky’s theories of generative grammars, and research in music semiology concerning syntax and construction of meaning, are considered. In the following I will first relate research on language and thinking, and then discuss its applicability to research on development of musical creativity.

According to cultural historical perspective, psychological processes can only be understood in their historical and social context (Vygotskij 1999). Unless there is social communication, there can be no development of neither language nor thinking neither on individual nor collective level. Hence, imagination and creativity are vital means for societal development, and crucial to the persistance of mankind (Vygotskij, 1995).

Imagination in Vygotskian thinking, is a combinatory skill wherein elements from reality are combined in new ways. Experience and emotion are interpreted by imagination. Through cognitive process emotion is conjunct to significance and meaning, which concludes
that thought and emotion are inseparable. Imagination forms a circle: Perceived parts of reality are transformed through imagination before they reenter reality, all according to Vygotskij (1999). Though the use of the concept of reality is somewhat problematic since it seems to imply an objective and stable external reality, in this text it is interpreted simply as an explicit form of an artifact; the percept to be transformed or the externalized outcome of the creative process. The study at hand focuses on this circular movement; how imagination works to create meaning through new combinations of elements of reality, and to build structures and concepts.

The interdependency of thought and language is fundamental to the development of mankind. Language as a vehicle for thinking enables us to define and objectify things and processes, and thereby to think in sequential steps and even build hierarchical structures of thinking, which is a prerequisite for planned activity, without which society as we know it would be unthinkable. Likewise, thinking is what raises the function of language above the level of simple signaling, that enables for levels of abstraction, generalization, planning and reflection. Through thinking, language is given predicative qualities; we can operate with expectation. In order to obtain emotional response, there must first be a complex cognitive process and several levels of structuring. John Sloboda (1985) makes a point in comparing the ability to understand a joke to the presumption of a musical progression. Both cases depend on a supposition of the course of events, based on cognitive structuring of grammatical as well as semantic properties. A musical passage can be repeated, varied, expanded, developed or contradicted. In every situation the user’s (be it a listener, an interpreter, a theorist or some other capacity) understanding of the available options of the chosen path and the relation of the path chosen to the structure, is affected reciprocally as well as predicatively, by this interplay between expectation, confirmation and deceit. Evidence of semantic qualities in music are to great extent found in the fulfillment or evasion of expected musical structural progression.

Noam Chomsky produced a theory of generative grammar that he claims to be a general property of mankind (Chomsky, 1973, 1965). The most widespread notion of this theory is probably the phrase denomination principle, which is usually depicted in the form an hierarchic tree-model where sentences are split into noun-phrases and verb-phrases down to the level of single words. This is then coupled with the somewhat less discussed transformational grammar, to deal forms and repositioning. These models are useful also to understand and describe important aspects of musical meaning, especially since they are meant to be general and independent of any particular language. They deal with fundamental functions of the mind and how information is structured into meaningful entities. These mental resources are probably part of most human activity. Although the claim of generality could appear to be in conflict with the cultural historic theory, this generality concerns a predisposition; it can only be realized through communication inside a culture and is then embodied in language, or perhaps music.

Quite a few have like Lehrdal & Jackendoff (1983) and Diana Raffman (1993) worked to adapt the theories of Noam Chomsky, especially the notion of generative grammars, into the music realm. Others, like Jean-Jaques Nattiez (1990), go further back, to structuralistic semiology to find their point of departure. The study at hand will examine the application of these concepts to a music pedagogical context.

Conceptualization; to understand something from a generalized point of view, is paramount to the learning process studied here. It involves a certain amount of generalization even when the object is a specific item. Vygotskij (1999) subdivides the process of conceptualization into several phases: In the first syncretic phase, objects are classified and ordered due to subjective casual impressions. Extraneous details become part of the perception of the object. The word is merely a part of the structure of the object. The second phase is the complex of thought, wherein there are actual and objective relationships between one object and the next, but the connections are associative and peripheral in a way to resemble a chain; there is no all-embracing principle involved. The complex is held together by a series of disparate and arbitrary connections that vary over time, whereas the concept relies on significant aspects common to all objects included. The complex phase could be further divided into associative complex that builds on casual connections, chain-complex which lacks a structural center and builds upon peripheral connections, diffuse complex in which connections are made from similar properties and lastly the pseudo-concept which resembles the true concept but its construction and creation is complex rather than conceptual.

Each concept forms a point of orientation for the mind and a collection of nodes for transfer to other concepts. A concept attains its meaning and value from the relationship to other concepts with the same level of abstraction. Its position in the system of concepts is also its level of generalization. Equivalence of concepts is when different concepts result in unison meaning. As the generalization level and the equivalence develop, the concept by and by becomes independent of the word, and the ability to remember a thought without words increases. This notion might be of central interest when adapting the structure of conceptualization process to the music domain.

It is interesting to note that on a structural level this cultural-historic notion of concepts is quite closely related to structuralistic linguistic theory. A fundamental aspect of the structuralistic theory as stated by Ferdinand de Saussure (1914) is that the sign attains its value from the position it holds in a system of signs. This parallel has had a great influence on the design of the study at hand as well as on the whole research project.

3. LEARNING FROM ALGORITHMS

Another foundation for the project is Dahlstedt's work on generative music, and theoretical framework for artistic creative processes (Dahlstedt 2010), which is based on experience from compositional processes using generative techniques, from research in computer-aided creativity, and from the study of musical output from computer models of creative processes.
A fundamental problem of creativity development is how to progress beyond what you already know; to extend your sphere of ideas in order to produce novel music. One approach to this problem is to engage generative and algorithmic processes. Such formal procedures have been used in many artistic genres throughout history to help generate artistic material (Dahlstedt 2004). They help the artist to manage the problem of infinite possible choices, by constraining the results through generative and restrictive implications, and they provide a path through the immense, and largely unknown space of possibilities. We use what we know to design an algorithm that projects into the unknown, because if the algorithm is of any significant complexity, we are not able to predict its results. And based on what we put into the algorithm, we hope that the interestingness will carry over into the remote areas of this unknown, potential music. The result is evaluated based on its aesthetic qualities, which we can judge by just listening to it. We refine the algorithm based on what we hear, and reimplement it until we are satisfied with the musical result. But the result is in some sense new to us. Its inner structure is only indirectly implied by the choices of the composer, through a complex chain of causality within the algorithm. Hence, the material may be pleasing, but alien to the composer. This phenomenon, discussed further by Dahlstedt (2001) in relation to the process behind his work for string orchestra, Kreatur (1997), leaves the composer with two choices. Either to accept it as it is, and present it as a finished work, which leaves the composer unchanged, or to try to assimilate the result. And if the inner structure of the music, its logic, is unknown to the composer, it may be very difficult to edit, extend, rearrange, or otherwise modify the music. To do this would require to gradually appropriate its style by repeated listening, and careful study, which takes considerable time. Only then has the algorithm extended his repertoire of musical ideas and range of expression. It has become internalized, and in future creative work it is an integral part of the creative process (Dahlstedt 2001).

4. DESIGN OF THE STUDY

The study took place within a course in composition in a music program in upper secondary school in Sweden, January to April 2010. It consisted from observations done in a quasi-experimental setting followed by interviews with the participants. The observation was twofold, considering both the compositional act and the artefacts deriving from it. It focused on the compositional process and sought to follow the settings for the algorithms to generate raw musical data, and the transformations of the musical materials. The interviews were centered around internalization processes and construction of meaning.

Students at a music program took part in a composition learning project, where they were introduced to working with generative algorithms for making raw material for musical composition. Then they went on to refine the materials, and transform and combine them into compositions. The research project concerns the appropriation process; how the students worked to accustom their hearing and understanding to the algorithmically generated material, what they choose to change, transform, add and omit.

In a series of seminars the students learned the basics of using a programming environment (Max/Msp) especially designed for working with music and sound. In the process they were given a set of music algorithms designed by the researcher to generate series of pitches, rhythms, chords and combinations of these, using different kinds of randomized processes. The setting was just like a normal class in a composition course: The students had a computer each and headphones for monitoring. The researcher/lecturer had a sound system and a projector to demonstrate and explain the algorithms and exercises. At the first learning stage, the students would just play around with the algorithms. In order to understand the nature of the effect and the possible scope of the outcome, they were to change the variables and data ranges initiating or restricting the randomized structures. Then they were to manually reconstruct the given algorithms for to understand the inner mechanics of them. Lastly they were encouraged to modify the algorithms and to connect different patches to form new generative processes.

After settling on what algorithms to use and the data ranges to assign to them, the students were asked to record the outcome into a traditional sequencer-program. In this environment, the task was to make music out of the random-generated raw materials by means of instrumentation and any kind of transformation. The students were asked to save the documents at every new work-stage, in order to supply data for observation.

The study was deliberately designed so that the students encountered tools of which they had no previous experience, and foreign musical structures they could only learn to control bit by bit. Then in the second phase of the project, they worked in an environment they were accustomed to and skilled in, doing traditional destructive editing, shaping the savagely raw structures into meaningful musical forms. In this stage they could play the recorded randomized structures over and over, and thereby get accustomed to the sound, whereas in the generative phase it would be different every time. In the sequencer-based second phase they were also encouraged to combine the algorithmically generated materials with compositional ideas of their own making. This design made it possible to study the conceptualization process from the beginning.

Finally the students were interviewed about their experience of the learning process; what choices they made, what algorithms they used and how they chose to set up and modify them, what musical aims they had in the algorithmic phase and if they managed to realize them. Another point of interest was how they treated the materials once they were recorded. What parameters did they edit and to what extent? In what ways were the randomized structures combined with traditional manual composition?

5. RESULTS

In the students’ first encounter with the programming environment they experienced chaos and disorder. The user interface did not resemble anything they were used to and it was hard at first to understand the nature of the different items. Furthermore, the first very simple algorithms they were presented with, produced some quite harsh music structures.
In the very first exercise, we used a metronome object to trigger a random generator connected to objects that turned the numbers into sounding notes. Possible manipulations were the speed of the metronome, the range of the random object (note-range), durations and register. After some exploring of the possibilities to adjust the input data ranges, the students were asked to reconstruct the algorithm. Then we did some variations and additions to the structure and continued to adjust the data ranges for these enhanced algorithms.

The students rather quickly learned the basics needed to handle these simple algorithms; to distinguish between the different work-modes, to understand the difference between objects and messages and basic principles for connecting these. Still there was a long way to go before they could ideate any musical ideas of their own in this environment. This learning situation fits the description of the syncretic concept (Vygotskij 1999) where knowledge is fragmentary and casual.

One of the students asked for algorithms where the rhythmic content could be changed or varied, which I consider the first explicit sign of connecting this learning situation to compositional thinking; a first step towards internalization. Up to this point we had only been working with randomized pitch, tempo and duration. In the second phase, we kept all the variables from the first stage, but focused on rhythmical structures. This was accomplished by using a denominator to the metronome, set to subdivide each beat by an adjustable range of values, but restricted to switch subdivision only by the pulses. To introduce the option of rest, a density parameter was included. The second phase went on like the first: The students learned to understand the algorithms by first altering data ranges, then mimicking the algorithms and finally modifying them.

At this stage the students began to manage the algorithms enough to steer the outcome in a way to resemble manually composed music, which need not be a goal but again, was a token of the internalization process. Credible musical structures helped to trigger the compositional imagination which made them useful for further elaboration. Two features were instrumental in furthering the concept development process: Instrumentation was put into play and some of the students lowered the musical tempo considerably. This made it easier to assess how ordering and tuning the algorithms affected the structural complexity. From observing the working situation, it seemed the mode of thinking was now rhapsodic and associative where casual and fragmentary before. These nuances are not easily proven, but that there had been a development from the first phase was quite clear to be seen and the students were now in the process of forming an image of the nature of the game. Individual variation was considerable of course, but more so in terms of musical aim, preference and ambition than considering the learning process.

For lack of space we now skip to the last phase of the project, where the students were to record the randomized structures into a sequencer program for manual editing. The observations now concern the artifacts; the actual compositions, rather than the working situation.

One of the students set the algorithm to play one single melody-line at a slow speed. She copied it to three different tracks and chose a pizzicato cello-sound to play it. In the first section the different voices were transposed to form a first inversion triad that was played in rhythmic unison. After this thematic head, the three voices formed a canon, still transposed and with small subtractions and edits made to the parts to make it more organic and less obvious as a canon. She had prepared for a forth part playing harmonies derived from the contrapuntal voices with a soft and mellow pad-sound, but ran out of time before it was realized. The process was first to restrict the algorithm to produce a quite simplistic and tangible melody, only then to blur that clarity by means of traditional techniques. This bears witness to a struggle to grasping and controlling the algorithms although the musical imagination calls for more excitement. The melodic line suggests a succession of tonalities and it is clear that the harmonies that result from the transposed voices are influenced by this linear structure. In this case the compositional process, though still in an early stage, is truly conceptual whereas the understanding of the random algorithmic structuring and the technical environment has not yet reached that level, but dwells in the complex phase.

Another student treated the algorithms in a similar fashion; he cut out the polyphony by reducing the algorithm until it produced a single-line melody, and lowered he tempo. Once the midstream was recorded into the sequencer, he built a sine-wave synthesizer-sound with an envelope to make it sound like a backwards recording. The melody was copied into two tracks but instead of transposing the notes, the synthesizers were detuned to form the interval of a major ninth and a quarter-tone. The two tracks were recorded into an audiotrack, which was then reversed to give it a bell-like sound; the reversed backward melody now sounded straightforward(!) The whole procedure was repeated and then recorded into a new audiotrack. This very brief example almost exhausts the catalogue of semantic tools applicable to musical phrase, presented by Sloboda (1985). There is repetition at three levels, variation inside the melodic fragment, vertical expansion in terms of transposition and the application of micro-intervals, and the retrograde is a form of contradiction. The document also had three more synthesizer tracks with elaborated settings for the instruments, but no music added to them yet. This hints that the work was interrupted by the ending of the project and that there were plans for a much larger piece. The focus on sound design and the way it was carried out, in terms of tools used and the nature of the sounds, points towards another study of the same research project, where this student also participated. This in itself is a token of the conceptualization process and an example of what Vygotskij (1999) refers to as nodes for transfer between concepts. The complicated design for this rather simplistic and minuscule piece of music, could be interpreted as an ironic meta-comment to the whole project, especially as this student in the interview stated that he was sceptic at first to let random and chance into his compositional toolbox but during the project he converted to the opposite position. Then again he also states that his focus now is to build whole compositions from very limited material, and there are indeed traces to suggest that this could be the seed for a larger construct.
To dwell a bit more on the interviews, the students stated that they learned to understand and handle the algorithms much in the way the design of the study was meant to provide for. One student was attracted by the idea of having uncontrolled streams of notes and rhythms possibly render beautiful music, and compared this notion to free improvisation. Though the final compositions were very strict in form, none of the students claimed to have a preconcept of the form, but it grew out of working with the material. To round off this section with a quote from the interviews: “Chance is beautiful and holds great artistic value.”

6. DISCUSSION

This study is part of a larger research project examining different aspects at different levels of learning composition and creativity development. For lack of space only parts of the study can be reported in this paper. Findings could be interpreted in terms of theories of concept development in language-based learning (Vygotskij, 1999) but connection between musical detail and analytical entity need and will be further examined. The intimate setting with a small group of students working almost as a team, discussing problems and helping each other out, has probably affected to narrow the span of variation in the results. The study should be repeated in different environments in order to produce a richer repertory of results. Another aspect is that the students would need more time than they were given in this project, to complete their compositions. That too probably could have rendered a greater variation of the outcome. Thus, assessment of the time-factor is an important part of method-development in the continuing project.

The interviews pose a certain problem to distinguish between actual and experienced learning and knowledge. Vygotskij’s theory discusses the close connection and interdependency between thought and emotion. But to empirically examine this would take a lot of effort in cross-referencing interviews with detailed observational analysis and to do several stages of interviews to follow up on relationships between words and action.

Relationships of syntactical aspects of musical meaning to learning and concept development need to be explored in greater depth and detail. Problems of musical syntax are interesting enough in themselves, but they also need to be more integrated to the study of the concept development process.

7. MOST IMPORTANT RESULTS

Among the most important results of the study were that theory of concept development in language based learning (Vygotskij, 1999) were applicable to music composition learning in this study. One aspect of this was that parallel to processes of disassembling and reassembling, reduction of musical information played an important role in the conceptualization process.

Meaning was assigned to the randomly generated structures by means of (quite strict) formal ordering, thematic processing at phrase level with emphasis on transposition, repetition and rhytmical disposition and last but not least, instrumentation and sounddesign.

8. REFERENCES