Structure as Performance: Cognitive Musicology and the Hermeneutics of Composition with Computers

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1. Introduction

In his essay "The Humanities as Sciences of the Artificial," Otto Laske points out that though the humanities "form a huge and, historically speaking, heterogeneous domain of research," there nevertheless exists among the humanities a common bond: all of them focus on a reality which is "artificial in comparison with the reality sought by the natural sciences."[1] [2] This "artificial reality is a result of design, whether one deals with a work or a social institution."[3] Pursuant to this overall view, the objective of Otto Laske's research has been to study musical works in order to determine "the intentions, designs, images, goals, and strategies of the generative processes that yielded them."[4] Laske's project in cognitive musicology considers, not only the work of art, but the cognitive processes by which it is realized (both for a listener and a composer). As such, Laske recognizes the failure of the standard theoretical paradigm by which objects (scores, sounds, etc.) are considered in isolation from the cognitive processes which give rise to them. According to the standard notion of music theory and analysis, an investigator extracts, from the object under scrutiny, structured models. These models take on meaning within the context of particular *cultural codes*. Thus, for example, a Schenkerian analysis of a score is understood in the context of hierarchical structural codes (hierarchical structures being a child of the Copernican/Newtonian model of the universe) as they are applied to similarly invented notions of harmonic progression. In like fashion, acoustical analysis of sounds yield coded messages in the form of signal representations[5] which reflect the premise that sound is an isolatable phenomenon.[6]

By contrast, cognitive musicology seeks to investigate the relationships between musical artifacts and the cognitive processes within which both individual and cultural codes are generated and integrated within a task domain. Cognitive musicology is not, therefore, an inquiry into the purely *behaviorist* aspects of musical performance. It is concerned rather with "the lawful, systematic link that connects behavior with the structural results it produces".[7]

In this essay, I wish to examine some aspects of Laske's theoretical work, particularly as they address issues related to the use of computers in music composition and sound

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[1] Laske ,1992, p. 239
[2] It should be noted that various engineering fields frequently focus on similarly "artificial" realities as well.
[3] ibid., p. 239
[4] ibid., p.239
[5] McAdams ,1987, p. 20; Kopec, 1989
[6] Laske, 1974, p. 35
[7] Laske, 1977, p. 3

synthesis. In the following discussion, I take what Laske terms a "procedural" view of music composition in as much as I am concerned with the "how" rather than the "what" of activities operating within musical problem domains. I therefore consider a musical artifact - be it an entire composition or a single sound - from the point of view of the design processes which yield it. A study of design processes entails the distinguishing of the environment in which such processes are engaged. As such, it is necessary to objectify the artifact within the context of its design processes in order to foreground the notion that such an artifact functions within a particular environment and according to the goals for which it is fitted. In order to substantiate this notion, I examine some issues in cognitive science and Laske's research and theoretical work in performance systems.

2. Toward a "Procedural" View of Music

To begin with, we first want to determine what is meant by “procedural.” In order to offer some insight, I first consider Laske’s notion of “design.” According to Laske (and to Cognitive Science in general), a design model renders ill-structured problems into particularized task domains in which competence and performance aspects of cognitive activity are combined in order to both define and solve those problems. In the following discussion, a model of memory is proposed that differentiates its competence and performance components within a larger cognitive framework. Such a model reveals knowledge as a process in which performances activate particular modes of competence.

2.1. The "Artifact" as an Object of Human Design

Herbert Simon has proposed a descriptive framework with which one might regard any type of human-made work, or "artifact."[8] He distinguishes an “artifact” as a phenomenon which derives from a system that has been "molded, by goals or purposes, to the environment in which it lives."[9] In contradistinction to "natural" objects, "artificial" objects (artifacts) arise from systems that are synthesized by human beings. While artifacts may be bound to certain laws as defined by the natural sciences, they differ from natural objects precisely because they function in relation to a particular goal, which is defined according to a humanly synthesized design.[10] Adaptation of an artifact to a particular goal is dependent upon "the purpose of the goal, the character of the artifact, and the environment in which the artifact performs."[11] Thus, for example, a clock functions as a thing by which we can tell time; its characteristic constructive principles may feature arrangements of gears and springs as acted upon by gravity or a circular grid with a thin spike at its center as acted upon by sunlight: the exact construction is in large part a function of its environment.

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[8] Simon, 1969
[9] ibid., p. ix
[10] ibid., p. 5
[11] ibid., p. 6

How an artifact performs (with respect to the function for which it is designed) depends on the "fit" between its construction and the environment in which it functions. As such, Simon speaks of the artifact as an "'interface' between an 'inner' environment, the substance and organization of the artifact itself, and an 'outer' environment, the surroundings in which it operates."[12] This allows an explanation of an artifact to be referenced to the purpose or function for which it is designed:

> Thus the first advantage of dividing outer from inner environment in studying an adaptive or artificial system is that we can often predict behavior from knowledge of the system's goals and its outer environment, with only minimal assumptions about the inner environment.[13]

Such a descriptive framework allows us to begin to talk about artifacts in terms of the functions for which they are designed. Central to this descriptive framework "are the goals that link the inner to the outer system."[14]

2.2. The "Ill-Structured" Problem

In order to study such systems, we begin by considering the nature of the specific problems which those systems address. "Well-structured" problems are problems whose specifications meet certain criteria. Such criteria include the requirement that the entire solution space (including initial problem state, goal state, and all intervening states) be definable. Problems which meet such criteria - "well-structured" problems - are relatively easy to represent with a General Problem Solver (GPS) and are thus regarded as "computable." In contradistinction, "ill-structured" problems are characterized, negatively, by their inability to meet such criteria.

Designing a house is an example of an ill-structured problem. For one thing, "there is initially no definite criterion to test a proposed solution" - the problem space is initially undefined.[15] The knowledge base representing possible solutions would have to include all possible materials, techniques, and design processes - a database of obviously prohibitive magnitude. Simon postulates that a design proceeds by transformation of ill-structured problems to much smaller well-structured ones. Such a process might be composed from a combination of a GPS (which at any given moment works on some well-structured subproblem) with a retrieval system, which continually modifies the problem space by evoking from long-term memory new constraints, new subgoals, and new generators for design alternatives.

Laske characterizes the structure of a problem according to the size of the knowledge base required for its solution.[16] As Laske notes, however, the size of the knowledge base is itself not the governing factor. Rather, the ill- or well- structuredness of a problem is determined by two entailments of a large knowledge base. First, a large knowledge base tends to yield a large number of different "representations of knowledge, any number of which might be simultaneously available to the performances of a problem-solver." Second, "a problem-solver

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[12] ibid., p. 7
[13] ibid., p. 8
[14] ibid., p. 11
[15] Simon,1973, p. 187
[16] Laske, 1979, p. 40

operating upon a large knowledge base is able to, or [is] forced to, redefine the problem space during the performance of a task."[17] How such a problem comes to be defined is shaped by the tasks of the problem solver. As a result, "problem definition and problem solution may come along together."[18]

2.3. Structural and Procedural Components in Memory

Problem-posing and problem-solving reflect activities which make use of memory. Cognitive research defines human mental activity in terms of data components, on the one hand, and programs, on the other. Laske calls these dual realms "structural" and "procedural." The structural component is comprised, roughly, of a database "where the stuff memory contains is stored." The procedural component consists of the "*interpretive* processes that use the information stored in the data base."[19]

When speaking of "structure," the assumption is that the performing system is, for the moment, suspended, at which point one may observe the data that has been processed so far. When speaking of "process," on the other hand, focus is on the actions of the performing system upon and within that data.[20] In terms of music, this "acting upon" is a matter of linking the perception of sound objects to more elaborate processing functions. According to an information-processing view of cognition, this occurs in two steps. First, sound is "pre-processed" and stored in various buffers until some representation of it is stored in longer-term memory. Second, that data is "acted upon" in some manner by a Central Processing Unit (CPU).

While it is unlikely that this separation of "structural" and "procedural" components actually characterizes the organization of human memory, it facilitates the investigation of certain issues regarding a cognitive musicology, the principle one of which asks: how are structure and process related in musical memory?[21]

2.4. Musical Knowledge

This question impinges on questions of musical knowledge. In order to frame a discussion of the structure of musical knowledge Laske begins by conceptualizing knowledge, in general, as constituting two distinguishable components: *competence* on the one hand, and *performance* on the other. Competence refers to "knowledge concerning the structure of the medium within which" particular activities are carried out, while performance refers to "knowledge concerning the ways in which this competence is utilized in the act of" carrying out particular activities.[22] [23] Operationally, competence constitutes "a set of concatenations of units forming a *musical structure*" while performance constitutes "a set of concatenations of such

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[17] ibid., p. 40
[18] ibid., p. 40
[19] Laske, 1977, p. 5
[20] ibid., p. 6
[21] ibid., p. 6
[22] Laske, 1973
[23] Chomsky makes a similar distinction with regard to language, relating *competence* to "the speaker-hearer's knowledge of his language" and *performance* to "the actual use of language in concrete situations." (Chomsky, 1965, p. 4)

operations as form a *musical activity.*"[24] In a general sense, competence refers to the "grammatical" while performance refers to the "strategical" aspects of the musical faculty.

A theory of musical knowledge accounts for both the grammatical and strategical aspects of musical activity, with the following stipulations: first, that "musical competence informs all musical activities irrespective of their strategical differences;" second, that "activities such as the production and/or recognition of sound structures are musical to the extent that they are demonstrably the actualization of musical competence."[25]

2.5. Competence/Performance as Framed by the Particularity of Tasks

Designing a computer-based task environment for music composition is tantamount to specifying a theory of performance. In a general sense, a performance model of music takes into account the "task specificity" of the processes according to which musical competence is evoked in the solution of particular problems. As such, we should understand competence and performance, not as different "types" of knowledge, but rather as "dimensions of one and the same knowledge being brought to bear on a task."[26]

Consider, for example, Laske's model of a musician (figure 1).[27] The musician is depicted as a system (M-System) which comprises three subsystems and which is itself embedded in a learning system (L-System). The three subsystems which constitute the M-System are:

1. a knowledge system (K-System);
2. a performance system (P-System);
3. an "understand" system (U-System)

The knowledge system is regarded as a "storage facility" which is constituted by a "declarative" component on the one hand, and a "procedural" component on the other. As described above, the declarative (i.e. "structural") component represents "assertional" knowledge about music, while the procedural component concerns the actual *use* of such knowledge in the performance of music-related tasks.

The "performance system" (P-System) specifies particular tasks. In this case, a "task" orients a sequence of actions taken toward the accomplishment of a specific goal. Once a task has been submitted at performance time, the "Understand system" (U-System) derives task-specific information (specific, that is, to the task at hand) from the K-System. This task-specific information takes the form of a "program." The submission of a task-oriented program to the U-System implies that the U-System is actually either an "interpreter" or a "compiler." As such, the U-System instantiates a General Purpose Program (not shown in the diagram, but running

[24] Laske, op. cit., p. 2-3
[25] Laske, 1973, p. 9
[26] Laske,1988, p. 3
[27] The following description is based on that given in (Laske, 1977, pp. 39 - 40)

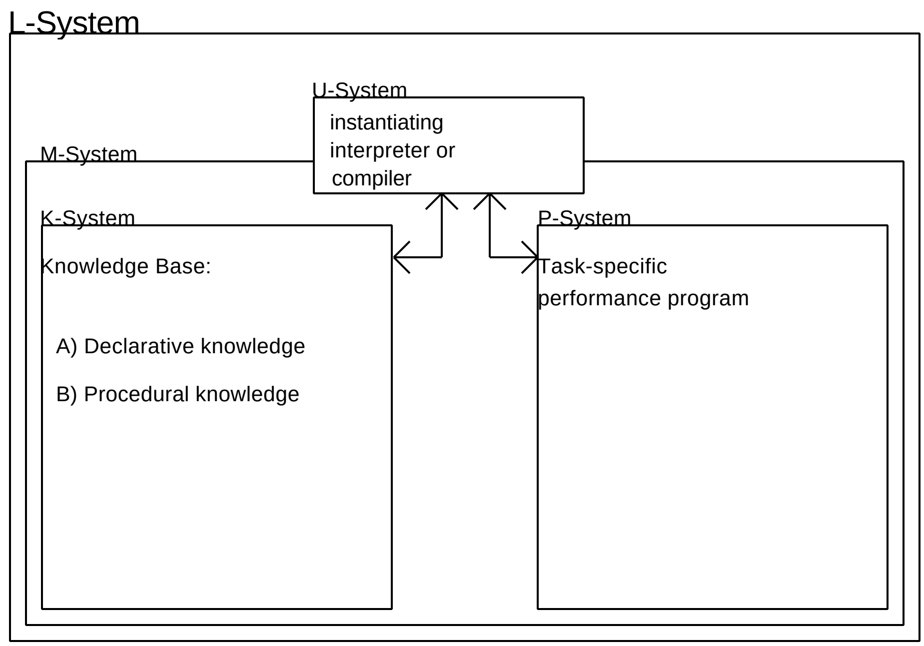

Figure 1

"in the background") along with the data structures associated with general music competence. In other words, *the U-System converts generalized data structures into those that are needed by the P-System for the performance of a particular task*.

These principles can be demonstrated with an example taken from (Laske 1988). Here musical competence is represented as a set of Prolog assertions, several of which represent an assumption of motivic competence. Under this assumption the musician understands a **motive-x** as comprising three tones, C#-D#-E):

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element (c#, 1, motive-x).
element (d#, 2, motive-x).
element (e, 3, motive-x).
length (motive-x, 3).
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Given this small knowledge base, the musician can ask any number of procedural questions, such as

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-?element(X,1,motive-x).   ;which tone is 1st?
-?element(d#,X,motive-x).  ;which position is d#?
-?element(e,3,X).;in which motive is 'e' 3rd tone?
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While any of such questions might be appropriate for the given knowledge base, it is significant that those questions actually considered "would depend on the problems the musician is solving, the musician's plans and goals, and the actual task environment (historical situation) in which the musician is working."[28] These particulars generate the conditions which, in turn, orient the tasks which engage the performance system of a musician. This is another way of saying that the particular problems, plans, goals, and histories which constitute the particular tasks defined within a performance system comprise the exact constraints with respect to which components of the knowledge base (both declarative and procedural) are instantiated (figure 2).

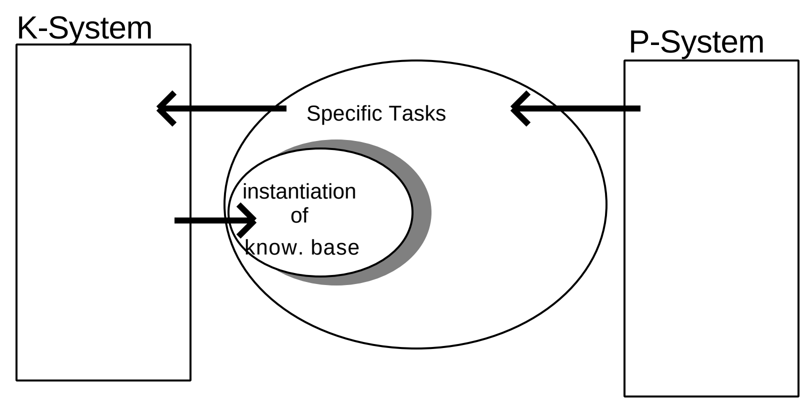

Figure 2

2.6. Knowledge as Performance

In this context, the performance of a designer (i.e. a composer) itself becomes a kind of "artifact" which functions as an *interface* between an "inner" environment, as represented by the knowledge system comprising his or her internal state, and an "outer" environment, as represented by the goals in relation to which the performance system is oriented and the tasks by which it is defined. In this regard, performance is as much a factor in the determination of knowledge as knowledge, *per se*, is a determinant in the nature of performance.

Such a notion evokes Humberto Maturana's description of the nervous system, which he defines as a "closed system:"

> Maturana describes the nervous system as a closed network of interacting neurons such that any change in the state of relative activity of a collection of neurons leads to a change in the state of relative activity of other or the same collection of neurons. From this standpoint, the nervous system does not have 'inputs' and 'outputs.' It can be *perturbed* by structural changes in the network itself...[29]

A "perturbation" is a point of intersection between a system which is defined as an "environment" and a system which is defined as the "organism."

Similarly, knowledge processes can be viewed as consisting of "perturbations" generated by specific actions within a task domain; a view which sees actions as constitutive

[28] Laske, 1988, p. 46
[29] Winograd, 1987, p. 42

agents in the activation of knowledge. From the standpoint of the human performer, however, knowledge and performance constitute a unity in which strategy and know-how are coupled. Each action engages both strategy and knowledge in a feedback loop in which, to some extent or another, each forms an input to the other. The precise nature of this feedback loop is determined by the task environment in which actions are generated.

Such a view of knowledge processes is at variance with the more common one which sees the knowledge system, per se, as generative of the task-specific knowledge used in the formulation and execution of actions. This classical view of knowledge processes is most prominently promulgated within the sciences of human/computer interactivity. It is this subject of interactive computing to which we now turn.

3. Frames for the Realization of Imagined Structure with Computers

As has already been mentioned, designing a computer-based task environment for music composition is tantamount to specifying a theory of performance. While a computer system, which assists in creative activity, activates an environment for formulating and executing tasks associated with the realization of particular goals, it also frames the intentions, designs, and strategies with which those goals are conceived and, finally, realized. As such, the computer is a tool which enables the composer to specify, in a more-or-less precise fashion, the processes and objects by which goals are imagined, formulated, and realized. To the extent to which a composer makes use of this potential, a computer system becomes a tool, not only for specifying particular artifacts (scores, sounds, etc.), *but for objectifying the very processes by which such artifacts might be modeled*. In this regard, the computer is potentially a tool for delineating epistemological frameworks in terms of which one might imagine and realize ideas.

3.1. Musical Memory

In order to begin fleshing out this hypothesis, which is of paramount importance in understanding Laske's conception of cognitive musicology, basic issues regarding human memory (as these are explicated in Laske's own writings) are first considered. In his research in human/computer interaction, Laske established criteria that were based on models of human memory.[30] Toward this end he established a model of human memory which defines three domains:

1. Temporal constraints;
2. Musical pasts;
3. Structure of human memory.

[30] The following description is taken from (Laske, 1979, pp. 41-43)

The first domain defines three levels of temporal constraints with respect to which musical events might be experienced. These are "audio-time", "conscious-time", and "interpretive-time." Audio-time refers to events that occur over time periods of a few milliseconds. Conscious-time refers to events which last between a fraction of a second and several seconds. At this level, significant features of an event can be registered in memory such that they can be remembered. Such events can be identified and tagged according to a large number of distinguishing parameters. These include frequency, timbre (characterized by a perception of the "overall effect" of events occurring at the "audio-time" level), duration, etc. Interpretive-time operates at "the highest level at which sonic events occur" and is "simultaneously the most complex level of all."[31] The term "interpretive" refers to the illusion of "lasting time" which occurs at this level of temporal structure and the fact that this illusion is "created by memory through interpretations of events on a high level of abstraction."[32] The term "interpretive" highlights the fact that structures perceived at this level result from internal interpretive processes which map themselves against a projected passage of time.

The second domain of Laske's model of memory distinguishes "two musical pasts."[33] First, there is the "*cultural past* to which a music and its associated conceptual and compositional software belongs."[34] Second, "there is the *immediate past* into which sounds perceived as music are projected by memory during listening."[35] This later is often called "musical context", which can be described as a "semantic model of the current auditory world of a listener."[36]

The third domain of Laske's conceptualization of memory specifies a model of human memory itself. This model relates to the three levels described above ("audio", "conscious", and "interpretive" time). Figure 3 depicts this model, which consists of a chain of submemories. Each successive submemory along the chain enables more processing time. So, for instance, "echoic memory" (EM) is a buffer which stores sonic events occurring in "audio-time" and is "pre-perceptual" - i.e. its contents become perceptible only after they have been stored in perceptual memory.

Perceptual memory (PM) defines events experienced in "conscious-time": these are events which last up to several seconds. Perceptual memory stores acoustic information in terms of a totality of its features - i.e. it stores it in "analog" form. By contrast, short-term memory (STM) stores such events as "tokens" that may be used in contextual memory for the purpose of syntactic grouping.

Working memory (WM) is the focal point of moment-by-moment processing: all processing decisions "are made on the basis of the transitory contents residing" here.[37] Such contents may be perceptual or contextual in nature, depending on the current problem to be

[31] Laske, 1979, p. 40
[32] ibid.
[33] Ibid., p. 41
[34] ibid.
[35] ibid.
[36] ibid.
[37] ibid.

solved. Such contents "define the musical present of which a musician can be conscious."[38] Working memory accesses the central processor (CPU) through short-term memory.

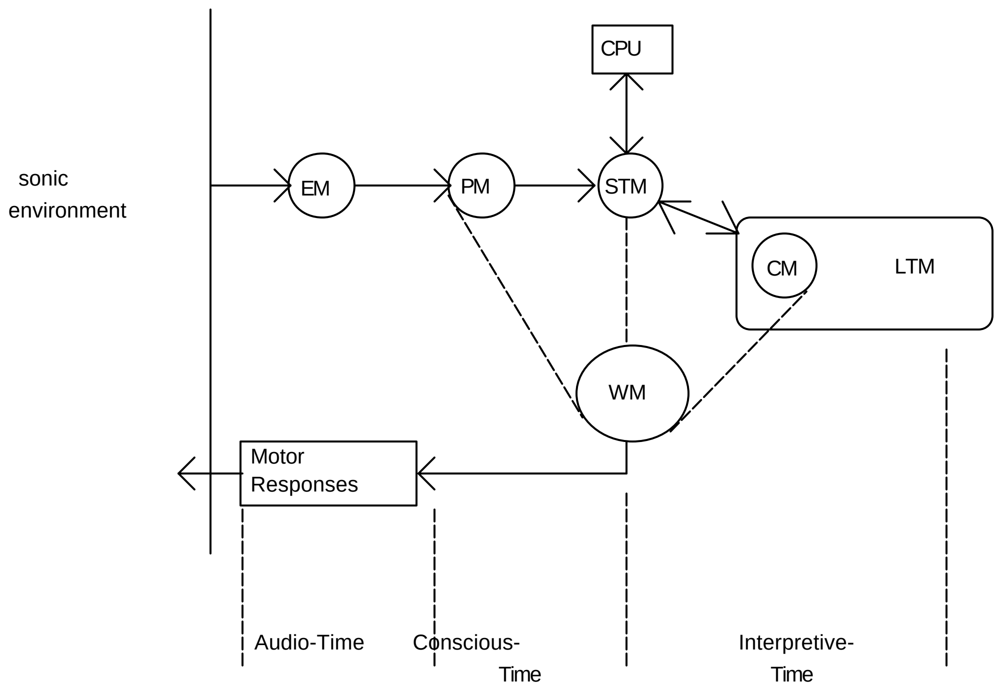

Figure 3

Contextual memory (CM) constitutes "the active portion of long-term memory."[39] Contextual memory "stores the context in terms of which individual events are conceptualized and understood."[40] For this reason, contextual memory "can thus be thought of as holding a model of the current musical world of a composer or listener."[41]

Long-term memory (LTM) contains information which defines a musician's "musical past."

Motor responses direct perceptual mechanisms in an effort to optimize the receipt of input information relevant to that which will help the cognitive system resolve conceptual conflicts, and to establish bodily responses according to the semantic concepts gleaned from the input data.

3.2. Syntactic and Semantic Considerations of Musical Memory

When considering human memory and its determination in human performance, Laske distinguishes those aspects of cognition that are *syntactic* from those that are *semantic*.

[38] ibid.
[39] ibid., p. 42
[40] ibid.
[41] ibid.

Syntactic concepts are those which define the various structural levels of a musical object or process. Semantic concepts, by contrast, define *interpretations* of those structural levels. Semantic concepts are constitutive of the temporal aspects of musical structure as well as the interpretive frameworks according to which relationships within and among such structures are defined. Such interpretive frameworks are dependent on structures according to which perceptual information is stored.

Music-semantic networks evolve through an *accretion* of moment-by-moment interpretations. At first, an initial input arouses an initial interpretation, which may be largely arbitrary. This interpretation becomes the basis on which further inputs are conceptualized. An *interpretive frame* - or set of "laws" - is constructed. Inputs which violate the integrity of this frame oblige the human agent to reconstruct some principle manifested within that frame; a cognitive action frequently requiring a retroactive "re-synthesis" of previously experienced input material.[42]

3.3. Action and Interaction

The manner in which constitutive inputs are rendered within the cognitive system are dependent in large part upon the way in which the organism "navigates", motorily, as a correlate to those inputs. Motor response systems help a human agent to correlate his/her internal state with the input information it receives and to formulate bodily responses with which the environment inferred thereof might be effected. A set of such responses are provided through what is called a *response function*.[43] These are functions (in the mathematical sense) through which a human agent (or any other organism) takes actions within the environment in which it currently exists.[44] As some aspect of the environment changes, so too do the outputs of the response function fitted to that particular aspect. When an organism changes its actions, the hypotheses - according to which the cognitive system conceptualizes inputs - themselves are changed. This change results from an alteration of the interpretive frame with which those hypotheses are semantically bound. This alteration of the interpretive frame, in turn, causes an alteration in the response function which orients subsequent actions, and so on.[45]

The resulting feedback structure constitutes an “interactive” system (depicted in figure 4). Each interaction given by the system is "embedded in a sequence such that

[42] Laske, 1979, p. 42
[43] Newell, 1990, p. 43
[44] Newell, 1990, p.43
[45] ibid., p. 44

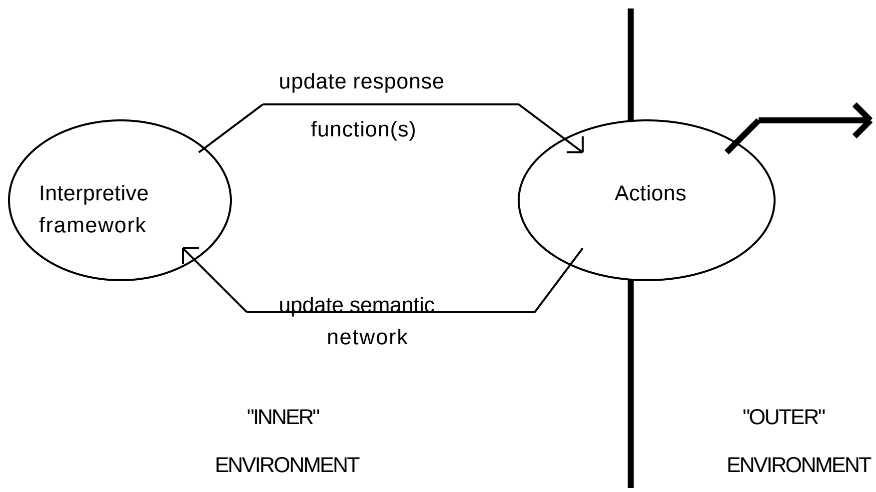

Figure 4

each becomes part of the context within which further actions follow" (figure 5).[46] As such, a single interaction is of itself meaningless in terms of its capacity for projecting functional information regarding the current environment or of the organism, since such a functionality is defined by a history of interactions.[47]

Two things effect this process:

1. the particular goal(s) specified;
2. the *task environment* in which tasks associated with the realization of those goals are performed.

The *goal* explicitly differentiates desired states from current states. A *task environment* encapsulates two "pasts" - the *cultural past* and the *immediate past* - plus a set of tools and materials, along with the knowledge conventions relating their use to the accomplishment of particular tasks. A task environment links two domains: the physical environment in which task performances are carried out, and an internal representation of that physical environment in the form of a problem space.[48] The *physical* task environment delineates a set of tools that are formulated along the lines of goals for which the task environment is fitted. A *problem space* defines a domain in which particular elements of a given problem (or task) are cognitively linked to their solutions by means of the tools given by the physical task environment. It is within this domain that tools are fitted to those tasks required to realize a goal. Both the response functions, and actions which arise from them, are framed not only by the goals at hand, but by the constraints generated by the task environment. The feedback loop comprising the resulting interactive system has the qualities as shown in figure 5:

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[46] ibid.
[47] ibid., p. 43
[48] Laske, 1977, p. 307

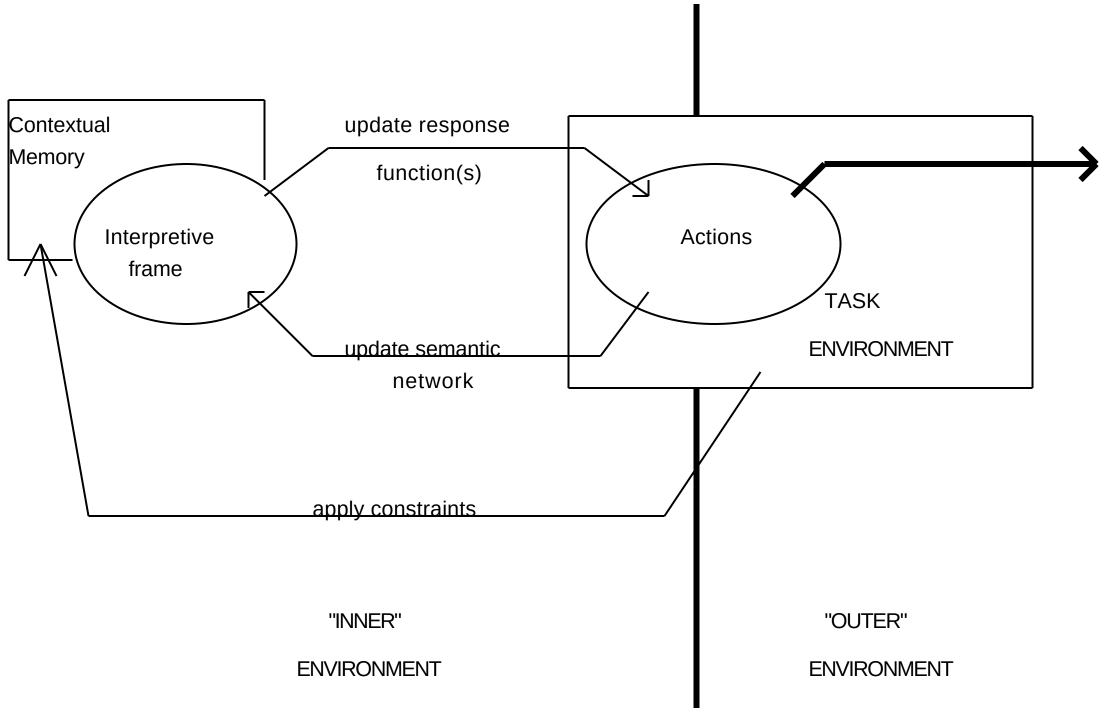

Figure 5

The task environment forms an input to contextual memory which in turn conditions the ways in which a cognitive system processes input information. The interpretive frame determines the set of laws according to which particular actions are formulated and carried out. The outcomes that emanate from the execution of actions, in turn, orient the framework according to which both elements within the task environment, and the goals and plans of a project, are interpreted.

3.4. Composition with Computers as Objectifying Compositional Process

Within such a system, the internal processes by which a human performs actions relevant to specified design criteria become fused with the procedural constraints defined by the task environment. As such, all actions constitute an “interpenetration” of the representations according to which design goals and design tools are conceived. The internal models formed by the human agent are as much determined by pertinent elements within the task environment as they are by the goals and plans directing the generation of artifacts. Such a system of interaction emphasizes the hegemony of particular historical methodologies while at the same time masking their presence through various forms of acculturation.

However, when a human is somehow enabled to construct elements of the task environment according to criteria that *s/he explicitly specifies* (as opposed to criteria dictated by historicity and methodology), s/he is in a sense “composing” the very means by which particular goals, and plans are framed. In this case, design criteria that are particular to a project become linked with the design criteria according to which the task environment is fashioned. Tasks obtain their particularity, not from some *implicitly* motivated historical "method", but from *explicitly* motivated criteria that are specific to the problem domain and design goals under consideration. As such, the environment acts as an *extension* both of that domain and of those goals; an extension that enacts *an externalization of internal processes*.

Computers are a powerful medium for investigating the means by which plans and goals become realized as artifacts. As a tool, they enable the explicit definition of design criteria according to which compositional activity might be carried out. For this reason, they have become valued tools for composers. To the extant to which composition is "a form of self-reference"[49], as Laske proposes, composition with computers is an attempt "at extending self-reference into the allo-referential domain."[50] The programmability of the computer gives it the potential of becoming an "intermediate between allo-referential and self-referential" domains.[51] To extend compositional activity (which is a self-referential activity) into allo-referential domains (such as computers and theories) is to make "self-reference a topic of the compositional problem", a kind of "meta-composition."[52]

In this context, composition consists in enabling a composer *to compose the very means (i.e. elements within the task environment) by which compositional activity might be carried out*. The operations and operands which define the task environment themselves become explicit by virtue of their being rendered as formalized elements within a symbolic system such as a computer. Such elements include programs, data structures as well as visual and interactive components. In such an environment, compositional hypothesis are determinative of both the artifacts being designed and the explicitly formulated processes by means of which those artifacts are designed. Constituted artifacts and their explicitly formulated design processes together project the internal processes of s/he who composes them. In a more abstract sense, then, *the self-referential is projected into an allo-referential domain*. Through such projection, the otherwise internalized processes of a human agent are externalized as though those processes were given by the task environment itself.

This *projective* potential of computer systems are their chief contribution to composition theory. It (a computer system) *imagines* us, by externalizing constraints that are otherwise merely implicit. In doing so, it *objectifies* - or *distinguishes* - aspects of ourselves that are otherwise non-distinguished, and therefore effectively invisible to us. This occurs by virtue of the fact that, in this capacity, computer systems force us to objectify ourselves by making us explicitly encode the processes by which goals and designs are to be imagined and realized. This calls us to understand that which we know "in such a way as to integrate it into a computer program"[53] or some other representational schema which the computer can understand. By this means the objectifying tendency of allo-referential domains forces us to "scrutinize the types of knowledge that underlie the object of our research"[54] in such a way that

[49] ibid.
[50] Laske, 1980b, p. 427
[51] ibid., p. 428
[52] ibid.
[53] Laske, 1992, p. 242
[54] ibid.

“we are modeling in an objectivist manner that part of our knowledge about the object that we intend to explicate.[55] Significantly, it

> is not the object that has [as a result] changed; it is us. *We have transformed ourselves into a partner of communication between two species of knowledge, one that is alive in us, and another that embodies us in the form of an external 'knowledge base'* [my emphasis].[56]

4 Conclusion

A computer system which itself engenders particular hypotheses of musical knowledge and performance problematicizes the interactions it engages. It does this by turning its focus away from already formulated (but not yet realized) musical objects to those whose formulation (and realization) is contingent upon the actions and decisions engaged within the interaction itself. Many classical computer music composition systems (such as Koenig’s *Project I/II*,[57] Xenakis’ *the Stochastic Music Program*,[58] Koenig’s *SSP*,[59] Brun’s *SAWDUST*,[60] and Berg’s *PILE*[61]) as well as some that are more recent (such as Kirk Corey’s *Ivory Tower*,[62] Eckel’s *Foo*,[63] Choi’s *The Manifold Interface*,[64] and Hamman’s *resNet*[65] to mention only a few) are designed along these lines. Such systems recognize the fact that computer systems are encapsulated theories. They are understand as means for hypothesizing musical knowledge and performance in ways which challenge traditional notions of what music is, and how a composer must proceed in order to make it.

As an adjunct to such systems, Otto Laske’s research has contributed, and continues to contribute significant insight since it explicates a cognitive and epistemological context for evaluating such systems, and the models of human activity that they project.

[55] Laske, 1992, p. 242
[56] ibid.
[57] Koenig, 1969; Koenig, 1970
[58] Xenakis, 1971
[59] Rowe, et. al., 1980
[60] Grossman, 1987; Blum, 1979
[61] Berg, 1979
[62] Corey, 1990
[63] Eckel & Gonzalez-Arroyo, 1994
[64] Choi, et. al., 1995
[65] Hamman, 1994

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