Navigating through Compositional Space: The Creativity Corridor

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Stravinsky once declared that the most frightening moment in musical composition was being faced with a blank sheet of manuscript paper. It is a moment when all options are open, and virtually all constraints are absent. It is rather like being on a boat in the centre of the Pacific—you can, in theory, go everywhere, but why should you want to go anywhere? This situation is often a typical starting point for much creative activity, such as musical composition or painting, but most design problems have this sort of starting problem as well (at least for the aesthetic part of the design).

Of course, most artists and designers do not actually start with a completely blank slate. Design problems usually have a functional element defined at the outset which provides some sort of focus or constraint (for example, a bridge is to be designed which actually has to connect two specified points and carry heavy traffic at the same time). In abstract music or art this focusing element is still there but is usually in a much weaker form—examples of constraints might include the musical forces at the composer's disposal or the broad shape of the work to be written.

From the blank sheet of manuscript there has to be a first step, then another, then another, and so on. How is the first step taken and how is the journey sustained? How does a composer know when the end is reached? In this paper we will examine the relative importance of various constraints—those imposed by human information-processing limitations, those resulting from the individual approach of the composer, and those resulting from the control of quality.

COMPOSITIONAL STATE SPACE

A musical work can be thought of as movement through a set of interconnected states from the beginning of the work to the end. A state (a concept borrowed from Artificial Intelligence [1]) is a particular instance of a set of values of all the variable aspects of music—notes, timbre, rhythm, loudness, harmony, tempo, etc. The complete state space covers all possible combinations in music—a vast space which makes the chess state space (all possible board positions in chess) look like a small local problem. A state change will always occur when an audible change takes place. In music, however, time is also a critical variable, and it is quite common for two states to differ only in time (for example, repetition of whole sections or even a phrase).

An example of a set of moves through the musical state space is shown in Fig. 1. Any circle in the space corresponds to a unique state. As a state is passed through, it becomes the current state, and at every state there is a set of available options as to what can be done next. In many state spaces there exists a set of defined "nearest neighbours." For example, in chess, there is only a small number of permissible states allowed by the rules of the game at any particular board position. In music the concept of nearest neighbour states is not so obvious, though "fashion" or the current sum of cultural musical experience will often severely limit the set of allowable moves. One function of a composer is to extend the set of permissible moves (like playing a game of chess and gradually altering the rule set). We will return to this later.

The listener hears a continuous set of state transitions as a work is performed. The composer creates this linked set of states within the huge state space of all available musical states. In traditional music, a state might be described by a vertical line through the printed score involving a set of notes, timbres, expression directions, rhythm markings and so on, defined at one point in time. Grafted on top of this space, however, is a further state space concerned with performance. Here, rhythm, tempo, expression and loudness are all varied within defined limits of the compositional space. In traditional composition techniques, the composer defines most of the state moves, but the conductor and players can provide additional state moves within this envelope. In some modern musical forms, the players have more control, or there may be random elements associated with state selection. In this paper we will concentrate upon the more traditional forms of composition and will not discuss the performance envelope further.

Composers fashion their sequences of state moves from a huge set of available musical states. Their start state is the "blank sheet of manuscript paper" together with any other constraints which apply at the outset. Their end state is much more difficult to define and involves a judgement of the journey through state space as a whole. Interestingly, in music, following the route through state space is the experience, and a composer has been successful when the audience does find (or at least has the potential for finding) the
journeying along the route satisfying in some way.

Navigation through such state spaces can be thought of as being controlled by what is called a "rule-based system" in Artificial Intelligence [2]. In such a system, a set of rules of the form

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IF {pre-conditions} THEN change state variables
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operates on the current state, causing a state change to a new state. The preconditions will involve a specific set of conditions of state variables (i.e. they define a set of permissible states on which the rule can operate) and the resulting changes in state variables define the new target state. Because of the pre-conditions attached to each rule, only a small set of rules is applicable to any one state.

Any particular state will therefore have a number of applicable rules. The game of chess has a finite set of such rules (for example, the queen can move in any linear or diagonal direction), but any rule can only be applied to certain states which match its pre-conditions (ones in which the player has a queen on the board and where that queen has free squares to move to). This set of applicable rules is called the "conflict resolution set." The key problem in moving through the state space is how to choose the most appropriate rule from the set in order to proceed towards a particular goal. Note that only one rule can be chosen. It is not possible to apply two rules at the same time.

In rule-based systems, the next move can depend purely on the current situation (a local rule) or upon the last few moves (a regional rule), or it can be part of some grand plan (a global rule). The problem in musical composition, as with the problem in chess, is which rule to choose from among all the possible rules which can be applied to the current state.

**NAVIGATION AND THE STATE SPACE HORIZON**

Composers must have an overall goal (or rationale) for choosing a particular way forward through the states. They will need to consider short-term moves, medium-term moves or long-term moves. As in a rule-based system, such moves will often conflict. Any actual move made will be a combination of trade-offs in priorities between short-, medium- and long-term planning considerations. Such considerations can be defined in terms of a "planning horizon"—that is, the distance from the current state to states involved in the planning decision. The three levels of planning, therefore, involve short-, medium- and long-distance horizons in the state space. A short-term horizon might involve changes of pitch, timbre, rhythm, or harmony. A medium-term horizon might involve a whole phrase or a theme. A long-term horizon might be concerned with the structure of the work (passacaglia, sonata) or a meaningful substructure (such as a development section). In Fig. 2, the black state is the current state, and the various horizons are illustrated.

In classical musical composition, the nearest neighbour states are quite well defined. To reach a remote key (a long-term planning decision) a composer might have to go through a whole series of medium and short-term plans to get there. In contrast, a more modern composer might accomplish the same move in one step. This fact might lead one to think that the musical space is becoming more free, that modern composers have many more options (or nearest neighbours) to consider, but this is not necessarily so. One crucial aspect of musical composition and other art forms is that mimicking the past is not usually allowable, except under very special circumstances. Thus, as music progresses, more state space changes become allowable but others become forbidden. The compositional problem is one of finding new possible moves in state space.

How do composers use these planning horizons in the composition process and which do they regard as the most important? One might think that the longer-term planning horizons always takes precedence. However, a particularly satisfying short-term option might cause adjustment to the long-term aims (this is where the analogy with a boat breaks down).

**GENERAL CONSTRAINTS ON NAVIGATION**

Any moves in the compositional space have to conform to some basic laws governing musical composition. These laws will arise from certain information-processing limitations in the human brain which dictate constraints in the state space moves. One well-known information-processing limit is that of short-term memory [3]. Human memory can be thought of as consisting of a short-term part (Short-Term Memory, or STM) and a long-term component (Long-Term Memory, or LTM). Although psychologists argue over the precise nature of these components, for our purposes this simple distinction will do. STM is used in conscious thought for holding short-term items (as when a person does a calculation or is asked to remember a telephone number). LTM contains a person's memories (such as names and episodes). It is well known that STM can only hold about 7-2 chunks of information at any one time. A chunk is more than an individual item. For example, if asked to remember the numbers 1 0 6 6, a person could remember four individual numbers, or chunk them into one item by remembering that they form the date of the Battle of Hastings. LTM also has interesting properties. For example, recognition is far superior to recall. Transference does take place between STM and LTM. One way of transferring is by rote—repeating a phrase over and over again until it "sticks." Thus, familiarity facilitates transfers from STM to LTM.

LTM offers more assistance in understanding music. It contains our experiences of music to date (current and past nearest neighbours). Thus, it offers sets of understandable nearest neighbour moves. Classical composition techniques offer conventional harmony, modulation,
time signatures and higher level structures such as the sonata form and the passacaglia. More modern techniques offer moves based upon, say, minimalist considerations or a rich set of percussion timbres. Composers are always endeavouring to add to our LTM store.

General constraints derived from the limits of human information processing are usually of a short-term or medium-term nature. They form a broad highway down which a composer should go in order to minimise comprehension difficulties.

MOVING DOWN THE TRAJECTORY

For music to be understandable, therefore, it will have to be designed so that it exploits properties of STM and LTM, so that the general short-term constraints will take the highest priority. Basic phrases must be short enough to fit into STM and must be repeated to enable easy transference into LTM, so that they can be accessed to enable understanding of later, more complex aspects of the composition.

There are many ways of facilitating understanding—e.g. using rhythmic, harmonic or sequence repetition or slight modification. Often a short theme or figure is manipulated in reasonably predictable ways. In Beethoven's Fifth Symphony, for example, the famous opening figure is repeated, inverted, and played forward and backwards in both its normal and inverted form many times in the first 57 bars, and the rhythm is relentlessly based upon that opening figure. Beethoven is writing within our STM limits and facilitating transfer to LTM. Later in the piece he offers recapitulation to make sure we have assimilated the essential elements of the composition. At this stage he can then develop the music, knowing that we have understood the building blocks.

The application of such rules is not Beethoven-specific, but they form part of a set of rules understood by both composers and listeners for developing figures and phrases. Their application considerably aids our ability to understand the work, exercises us and prepares us for much more difficult transformations later. Of course, after sufficient repetition, the composer can assume that the phrase will now form a chunk, and larger units can be offered to the listener.

Even a short, memorable song is built up of much smaller fragments developing within the above STM and LTM exploitation rules. Take a very simple piece by Jeremiah Clarke (Fig. 3).

The broad structure is clear even on the musical page. The opening statement is in bars 1 and 2. Three crotchets are followed by two descending quavers in the first bar. In the second, the content is the same but their position is altered. It is likely that the first three notes are a "chunk," which is followed by a rhythmic chunk (immediately repeated) and a final crotchet. Note that the rhythmic chunk is immediately repeated, perhaps assisting its assimilation into LTM. Bars 3 and 4 provide a repeat (with slight variation—introducing two rising quavers which will be used later), emphasising the pattern again. Bars 5 and 6 repeat the opening statement (which rams it into LTM). Now the composer can begin to develop (in fact he has to, or the work will become boring and predictable). In bars 7 and 8 the rising quaver phrase is repeated (giving us a new element to play with) before a crotchet, followed by the descending quavers, ending with a nice variation which introduces the dotted crotchet. In bars 4 and 8, LTM knowledge of harmony is appealed to through the use of the tonic and dominant with a cadence at bar 8.

Now we can really launch out into state space. The opening phrase is modified to the dominant and the repeated quaver phrase added in the treble and bass to give a run of eight quavers. Bar 11 switches to the tonic, mimicking bar 9, with bar 12 using the repeated ascending quavers. In bars 13, 14 and 15 we are really travelling. The bars have combined the figures to give a continuous stream of quavers. LTM is backing the action with switches between dominant and tonic, culminating in a final satisfying cadence at bar 16.

One can see a highly calculated approach to exploiting STM and LTM with a structure which starts simply but is quite complex by bar 14—and all built up in small, understandable moves.

Note that music is not just a matter of producing memorable patterns, however. It is quite easy to produce music which can be remembered and understood. Beethoven could simply have repeated that opening phrase 150 times. It would certainly have been remembered and followed. However, it would not have been called great music. The composer treads a knife edge between being "boring" or being far too complex. The music must be followable—but only just.

AN INDIVIDUAL COMPOSER'S VOICE AS A CONSTRAINT—THE CREATIVITY CORRIDOR

Another constraint is obvious to all who enjoy music: most musical composers have a definite "voice" which distinguishes them from others. This voice can be thought of as a set of fixed constraints which limit the conflict resolution set and therefore severely limit moves in the space. The existence of this voice enables us to say which composer has written a piece of music even if we have never heard the piece of music before. Once these voice constraints are known, it is possible to generate music which sounds tolerably like the music of a particular composer (usually poor music, because quality involves other rules).

The development of this unique voice imposes "trajectory constraints" on the paths through state space. Composers develop such constraints only slowly, and at first they tend to be imitative (i.e. based upon other composers' constraints). Once an individual style has developed, however, it seems to remain fairly fixed. One way of finding out the importance of the different horizons is to take a number of sections from a composer's work and determine in what sense the extracts still identify the originator, if at all. If we do this for a mature

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**Fig. 2.** Planning horizons in the state space. The black state is the current state, and the various horizons are illustrated.
(traditional) composer, we get an extraordinary result. We can take almost any reasonably long segment of the path from the total set of interconnected states of a musical work and, even if we analyse each in isolation from the whole path, we will usually recognise who the composer is. In most cases, a recognizable fragment may be as small as a few bars or steps. We do not need to hear a whole work to know who the composer is. The extraordinariness of this fact might be exemplified in the boat context. In that metaphor, it is as if we could determine who was rowing the boat from a small sample taken from any part of the boat’s route across the Pacific.

An interesting issue is which horizons are most involved in defining the voice. It is likely that the development of this voice relieves composers of short-term issues and allows them to concentrate on medium- or large-scale planning. The voice defines a clear set of nearest neighbours in the space, forming a sort of “creativity corridor” within which composition takes place. The creativity corridor is an intriguing constraint. Why should not a modern composer create music in the style of Mozart’s by adopting his corridor? After some time of intensive study, the nature of Mozart’s voice could be made explicit and exploited. However, it is likely that people would not take such work seriously. They would say in a derogatory manner, “It’s just like Mozart,” and then go on to say how wonderful Mozart’s music is. Why is such a style acceptable when Mozart does it but not when someone else does it? Ironically, the more the created music was to sound like Mozart, the more it would be described as imitative.

My own case is probably an interesting one because, although I was trained in piano playing, I am, essentially, a self-taught composer. I do have a distinctive voice (I think that one can tell that a work has been written by me, but it is still to some extent derivative) but the development of my voice was an unconscious process which I can now only see in hindsight.

The voice is at least partially based upon the absence of the third interval (major or minor) and is grounded in clusters such as CDFG or bare fifths and fourths. There are also frequent moves in four whole-tone steps. Looking back at some early work (1956) there is a preponderance of such cluster chords and sequences. With hindsight it is clear that these chords are striving to avoid traditional harmony, the absence of the third providing a major/minor ambiguity and weakening the tonality. This idea certainly was not in my mind when I began to compose this way, but it is an obvious solution for navigating the space and avoiding states connected too strongly with conventional harmony. The bare fifth, of course, is regarded as rather bad form in conventional harmony.

Much later (1970) there seemed to be a change in this voice, the music now having a preponderance of double fourths such as DGC. However, musically, this is the same voice. Any musical theorist would have immediately seen the similarity, but the point I am making is that, at the time, I knew no theory. My creativity corridor had actually not changed significantly.

There are other features which go into the making of a voice, such as short rhythmic ideas or even timbre combinations (Shostakovitch, Britten or Walton come to mind here), but the individual voice is a severe (though quite local) constraint. In fact, the short-range nature is a great advantage. It cannot be too far-ranging, because if it were we would not be able to identify it so readily and so quickly, and it would get in the way of structural development. If a composer’s imprint required many bars, he or she would be denied many developmental devices in music. It seems thus reasonable to conclude that the constraint of individual voice is a powerful one, but usually short-range. In the navigational analogy, it might be akin to how the navigator walks, his or her bearing, how people are treated on the way, etc.

The voice constraints are imposed within the general highway already discussed. They are the next rules to be applied in the order of priorities. Space precludes us from analysing the application of a voice in detail here. However, obvious examples come to mind—the leaping sevenths of Walton, the adjacent major/minor shifts of Vaughan-Williams and the chromatic sliding tonality of Delius.

**THE ACHIEVEMENT OF QUALITY**

It was mentioned earlier that the voice rules could produce music of a certain characteristic, but that this did not guarantee quality. This paper has seen composition as the interplay between different sets of rules (general and voice) as the compositional space is navigated. Described in such a way, the compositional process might be thought to be almost mechanical. The compositional rules just described would have their equivalence in the real navigational situation as journey planning, fuel conservation, a particular way of dressing the
ship, etc. However, there is another factor, undoubtedly the most important: that of maintaining quality. The whole process is observed and judged, not as to whether a planned-for port was reached, but as to how the route was navigated. Composers can put into the wrong port provided they navigate the journey with "quality." If, however, a composer reaches the right port in the wrong way, failure is almost inevitable.

But what do we mean by sailing the journey with "quality"? It has already been pointed out that there is a very easy way to make the audience completely follow the music written. Take a simple pattern and repeat it without variation—or, have a very small number of rules with which to navigate the space. Unfortunately, this is not regarded as stylish. The answer is, of course, to be sufficiently predictable to allow understanding but sufficiently unpredictable to prevent boredom. Indeed, it is the unpredictable part which gives the music its "kick" or "excitement," and clever composers play with the predictable and unpredictable to manipulate their audience. This uneasy tension between technical competence and artistic inspiration was identified by W. H. Auden, who, when he wrote to Benjamin Britten, suggested that great art was a perfect balance between Order and Chaos, Bohemian Chaos and Bourgeois Convention. Bohemian Chaos alone ends in a mad jumble of beautiful scraps. Bourgeois Convention alone ends in unfeeling corpses. Every artist except the supreme masters has a bias one way or the other. . . . Technical skill always comes from the Bourgeois side of one's nature [4].

Whenever one is "stuck" during composition, initial forays into the compositional space tend to be cliché-ridden. What is a musical cliché? Almost certainly, it is an overused rule. How a composer decides that a particular move is exciting or interesting is a really difficult question to answer. Perhaps it comes from some peculiar connections of the neurons in the brain. A good composer does know a "good" transition when heard. Composers struggle for days with "acceptable" material and then, suddenly a really good solution will present itself and there will be no doubt as to its worth. Thus, the central issue in quality composition seems to be that "conflict resolution" activity mentioned at the beginning.

Thus, our rules of composition have to incorporate this chaotic element. The voice has to be used to exploit this unpredictability. I tend to compose at the piano, which is regarded by many composers as very bad form, because this approach limits musical thought. However, when combined with my poor ability as a pianist, it results in an unexpected benefit. Frequently during my state space excursions I hit "wrong" notes and these are often an excellent source of new ideas. The technique requires a degree of competence. You have to be a sufficiently good pianist to hit most of the right notes (otherwise the transitions are too random and difficult to follow). Then the mistakes show as relatively minor variations in the state space, some of which can be exciting or interesting moves.

Medium and long-term horizons are almost exclusively concerned with quality. One might term them organising principles. It is these long-distance horizons which allow a work to hold together, relate one part to another, and control development of the piece. Examples might include the exciting use of old material in a new way, combining apparently unconnected earlier fragments into new meaningful statements, or making transitions between major statements. Examples of such principles would be the "additive process" and "cyclic structure" techniques used by Philip Glass. In additive process, a simple figure can be expanded and contracted with the addition or subtraction of notes while maintaining the general melodic configuration. In cyclic structures, two different rhythmic patterns are superimposed with different lengths. At some future point they arrive back together at their starting points [5]. Such rules are very difficult to explicate or justify, but they lie at the heart of the meaning of creativity.

CONCLUSIONS

The state space concept seems to be a useful vehicle for discussing the relative roles of planning in the development of a musical composition, and the rule-based approach provides a convenient way of describing moves through the space. First, there are rules which are essential in order to best utilise the information-processing capabilities of the human being. These are short-range (exploiting STM) and long-range (exploiting LTM). Second, any composer requires an individual voice in order to reduce the complexities of the compositional space. This tends to be short-range in nature, allowing maximum freedom in the use of musical structures. Finally, there are medium- and long-range rules concerned with quality, a concept difficult to define.

References

5. Philip Glass, Opera on the Beach (London: Faber and Faber, 1988).