CHAPTER 9 -- *Phrase Garden* —

When Cinderella's Monkey Comes Here, I'll Feed Him

9.1. Overview

The composition entitled *When Cinderella's Monkey Comes Here, I'll Feed Him* (Tracks 4 to 6 on the accompanying audio CD) is a programmatic work focusing on the individual development of human character traits. Cinderella is a metaphor for the inner beauty of the human character, and also, in keeping with the original character of Cinderella, a metaphor for human melancholy. The Monkey is a metaphor for the dark traits of the human character, for example, paranoia and jealousy. *When Cinderella's Monkey Comes Here, I'll Feed Him* (herein abbreviated to *CM*) is in three movements, the first related to the character of Cinderella, the second to the character of the Monkey, and the third representing, in a positive light, an acknowledgment of the various character traits associated with the Monkey, hence the title of the work. Throughout the work, the character of Cinderella is portrayed with a programmatic focus on beauty and melancholy. The character of the Monkey is portrayed through a programmatic focus on two sub-characters: an unspecified demon, and a Harlequin-like trickster. Table 9.1 shows a breakdown of the programmatic associations, with corresponding measure numbers for each movement of the work, the measure numbers provided with reference to the full score provided in Appendix 4.

Table 9.1 *CM,* Programmatic associations

Measure #	**Programmatic Association**
Movement I	
1-24	Beauty and Melancholy
25-32	Melancholy
33-47	Beauty
48-78	Melancholy
79-110	Beauty
111-26	Beauty and Melancholy

Table 9.1 (cont.)

Movement II	
1-21	Trickster
22-50	Demon
51-91	Trickster
92-140	Demon
141-65	Trickster
166-83	Demon
Movement III	
1-16	Beauty
17-72	Melancholy
73-132	Trickster
133-71	Demon
172-96	All

The composing of *CM* was carried out in three stages. In the first stage, interval weightings and interval sets were defined for phrase development in *Phrase Garden*, along with sets of rhythmic cells that would map to intervals defined for use within *Phrase Garden*. In the second stage, *Phrase Garden* was used to (a) search the genetic space of phrases for specific parts of *CM*, (b) generate series of phrases based on sets of interval weightings with the *Phrase Garden* Variation Mode, and (c) generate phrases in which interval content varied over time with the *Phrase Garden* Mutation Mode. The final stage entailed the editing of the *Phrase Garden* output within *Finale* notation software, the *Finale* output used for performances of *CM* with the acoustic instruments of Bb clarinet, piano and percussion.

The following sections relate the processes involved in each of the three composition stages. The intervals and rhythms defined for use in *Phrase Garden* are detailed in Section 9.2. Section 9.3 relates the manner in which *Phrase Garden* was used to develop phrases in *CM*, and also relates the manner in which the use of *Phrase Garden* provided alternative methods of composition to those used in the compositional style outlined in Chapter Seven. Section 9.4 briefly relates the manner in which the *Phrase Garden* output was edited in *Finale*.

9.2. Composition Structures

9.2.1. Pitch structures

Pitch materials in *CM* are a direct result of interval sets defined for phrase generation in *Phrase Garden*. In general, interval sets are intuitively derived, but usually with some reference to the programmatic content of the work. Defined interval sets are limited to the intervals 1 through to 6. Interval leaps larger than the interval of 6, common in works developed with the compositional style, are provided through the use of *Phrase Garden's* Octave algorithm, or through the use of *Phrase Garden's* Mutation Mode in combination with the Octave algorithm.

In the first movement of the work, an interval set of 1 2 5 is used, this set expanding with the addition of intervals 3 and 6 before the middle of the movement (m.56), at which point the interval 4 is included, providing an overall set of 1 2 3 4 5 6. The interval set 1 2 5 is derived through a personal association of the intervals 2 and 5 with the beauty and melancholy of Cinderella, while the interval 1 is associated with unrest and Cinderella's dissatisfaction with her situation. The addition of the intervals 3, 4 and 6 is primarily made for melodic variation. Interval weightings possible with *Phrase Garden* provide a focus on the intervals of 1, 2 and 5 throughout the movement. The interval 1 is weighted most heavily, with a minimum of 40%, intervals 2 and 5 follow with a minimum weighting of 20%, whilst intervals 3, 4 and 6 are weighted minimally at either 5% or 10% only.

Interval sets in the second movement are defined in two separate ways: one for the Monkey-based character of the demon, and another for the character of the trickster. The demon character is generally assigned an interval set of 1 5 6. Similarly, the character of the trickster is assigned an interval set of 2 3 4, however, in accord with the trickster character, this interval set is altered unpredictably throughout the movement and results in interval sets that may contain any interval from the set 1 2 3 4 5 6.

The third movement presents interval sets based on the sets of the former two movements, although there is some expansion of the interval sets associated with the character of the Monkey, in keeping with the programmatic acknowledgment by Cinderella of the Monkey within her own character. Table 9.2 shows the sections and measure numbers of table 9.1 with the interval sets defined for each section of the work. Where interval sets differ between instruments, the standard instrument abbreviation (cl. is clarinet, pno. is piano and mba. is marimba) is given in brackets to denote which instrument is using a particular interval set. The final section of the third movement is a coda to the entire work, and presents an intuitively composed collage of previously stated materials from each movement. The interval sets used in this section are merely repetitions of formerly presented sets and no new or varied interval sets are presented.

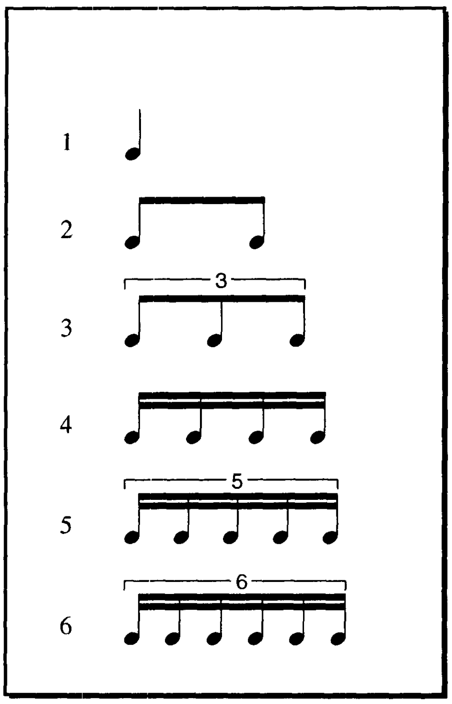
Table 9.2 *CM,* Programmatic associations and interval sets

Measure #	**Programmatic Association**	**Interval Set**
Movement I		
1-24	Beauty and Melancholy	1 2 5 1 2 3 5
25-32	Melancholy	1 2 3 5 6 (cl.)
33-47	Beauty	1 2 3 5 6
48-78	Melancholy	1 2 3 5 6 1 2 3 4 5 6
79-110	Beauty	1 2 3 5 6
111-26	Beauty and Melancholy	1 2 3 5 6
Movement II		
1-21	Trickster	1 2 (cl.) 1 4 (pno.) 1 3 5 6 (mba.)
22-50	Demon	1 4 5 6
51-91	Trickster	2 3 4
92-140	Demon	1 3 5 6
141-65	Trickster	2 3 4
166-83	Demon	1 5 6
Movement III		
1-16	Beauty	1 2 5
17-72	Melancholy	1 2 3 5
73-132	Trickster	1 2 3 4
133-71	Demon	2 3 4 6
172-96	All	Various

9.2.2. Rhythmic structures

Rhythmic structures throughout *CM* are generated in *Phrase Garden* in association with the interval sets used in the work. Rhythmic mappings to each interval vary from movement to movement, from section to section, and at times from one phrase to the next. In general, rhythmic mappings in *CM* are similar to the rhythmic mappings used in works composed with the compositional style, with each interval used in *CM* initially assigned a rhythmic cell that reflects the interval value itself, as shown in Figure 9.1.

Figure 9.1 *CM,* Initial rhythmic mappings



Alterations to rhythmic cells in the compositional style, through the use of augmentations, diminutions, and the replacement of rhythmic values with rests, are only possible in *Phrase Garden* by defining rhythmic cells that include such alterations. In the development of rhythmic cells for *CM*, numerous possible cells were defined for each interval, cells that contained the augmentations and diminutions of the initial cells shown in Figure 9.1; and cells that included rests were also defined. Figure 9.2 shows the range of cells associated with each interval used in *CM*, with individual cells separated by commas.

Figure 9.2 *CM,* Rhythmic cells

Notable in Figure 9.2 are the long rhythmic cells, mapped to a single interval, that incorporate cells from other interval to rhythmic cell mappings. An example is the final cell defined for interval 1, in which there is a 1/16th note triplet figure, normally associated with interval 3. Such rhythmic cells are defined to provide rhythmic variety in *CM* when the incorporated cell does not appear in a currently used interval set. An example appears in the opening section of the second movement of *CM.* Here the programmatic focus is on the character of the trickster, and as such, the section requires a high degree of rhythmic activity and also a high degree of melodic dissonance. In the clarinet part, with the interval set 1 2, the dissonance is achieved with a heavy weighting on the interval 1. However, the rhythmic mappings to this interval, with a minimum value of a dotted 1/8th note, are generally too long to suit the section. This is with the exception of the final cell in the interval 1 mappings, in which the 1/16th note triplet provides a rhythmic activity for the section that is not available with the remaining cells mapped to the interval.

Throughout the composition of *CM*, the choice of rhythmic cells used with a particular interval set was usually made in relation to the programmatic content of a section being composed. In general, the character of the Monkey, with the associated sub-characters of the trickster and demon, is portrayed with the more rhythmically active cells containing rhythmic values of 1/32nd and 1/16th notes. The melancholy of Cinderella, alternatively, is portrayed with less rhythmically active cells that contain values of an 1/8th note or more, or a combination of long and short rhythmic values such as the 1/16th note quintuplet cell comprised of an 1/8th note and three 1/16th notes.

9.3. The Application of Algorithms

9.3.1. Phrase searching

Numerous phrases in *CM* are the result of searches, in *Phrase Garden*, through the genetic space of phrases based on a single interval set with pre-defined interval weightings. The design stage for such searching entails the definition of intervals and interval weightings in the *Phrase Garden* Variation Mode, the selection of a desired pitch range, the setting of a phrase length, and the input of a seed pitch. When a phrase is desired that begins on a particular pitch, a Phrase Generate setting of anything other than 1 to 1 is set, but usually a setting of 1 to 2 is used. This setting provides two phrases, the second of which will begin on a different pitch, and is generated after the playing of the first phrase. If, after playing, the first phrase is deemed unsatisfactory, the System Reset button is clicked, so that both phrases are deleted and the desired starting pitch can be used again as a seed pitch. Usually, the re-entering of the desired starting pitch will result in a first phrase that is different from the one formerly produced, with the new phrase presenting a different interval ordering but the same starting pitch.

In *CM*, the opening clarinet phrase (mm.5-6) is the result of a search through a number of phrases in this manner. The desired phrase was to contain the intervals of 1 (50%), 2 (25%) and 5 (25%), was to be a length of 15 pitches, was to be set in the lowest register of the clarinet, and was to have a starting pitch of D below middle C (D concert pitch). The pitch range set was from D2 (D below middle C) up to F3. Pitch movement in the phrase was to be generally ascending, achieved through the setting of an upward interval direction for the interval 1, but with interval skips and leaps that were either ascending or descending, achieved with the either up or down interval direction setting for intervals 2 and 5. It would conclude with a pitch in the upper limit of the set range. Rhythmic content of the phrase was to contain 1/32nd notes only, this rhythmic value assigned to each interval in the p rhythms sub-patch. Figure 9.3 shows the interval content of five phrases searched. On playback of the phrases, the initial four phrases were found unsatisfactory as the final pitch in each was not in the upper limit of the desired pitch range; however, the final phrase was satisfactory as it fitted the criteria.

Figure 9.3 *CM,* First movement, mm.5-6, clarinet, phrase interval content

Phrase 1 - 2 1 5 1 1 1 1 2 5 1 1 5 2 5 5
Phrase 2 - 1 2 1 5 2 2 2 1 2 1 1 1 1 1 5
Phrase 3 - 1 5 2 2 2 2 5 5 1 1 1 5 1 1 5
Phrase 4 - 1 1 1 2 2 1 2 5 2 1 1 1 5 5 1
Phrase 5 - 5 1 5 1 1 1 5 2 1 2 2 1 1 5 2

Another phrase search was carried out for the subsequent piano phrase of mm.9-10. The desired phrase was to act as an exposition of rhythmic cells associated with the intervals 2 and 5 (two 1/8th notes and an 1/8th note quintuplet respectively), whilst containing the interval set of 1 2 5. The interval 1 was assigned a rhythmic cell of a single 1/4 note. A Phrase Length setting of 7 was used, intervals were defined with the same weightings as used in the previous clarinet phrase, and interval directions were all set to the either up or down direction setting. A pitch range of Bb4 up to F6 was used, providing pitches in the mid-upper range of the piano.

Figure 9.4 shows the interval content of four phrases generated with the above settings. With a phrase of seven pitches, there can only be a statement of the first seven rhythmic values mapped to the interval set. The intervals in the first phrase of Figure 9.4 provide a quintuplet 1/8th note figure from the interval 5 mapping for the first five pitches, followed by a single 1/4 note from the interval 1 mapping for the sixth pitch, and a single 1/8th note from the interval 2 mapping for the seventh pitch. This first phrase was unsatisfactory due to the second interval generating a 1/4 note value, when the desired phrase was to contain the exposition of the quintuplet and 1/8th note rhythmic cells only. In order for a phrase to suit the desired criteria, the initial two intervals generated must be either 5 2 or 2 5. Phrases such as the first three in Figure 9.4 are, therefore, unsatisfactory. The final phrase, beginning with the intervals 2 5 fits the desired criteria.

Figure 9.4 *CM,* First movement, mm.9-10, piano, possible phrase interval content

Phrase 1 - 5 1 2 1 2 1

Phrase 2 - 1 2 5 5 1 1

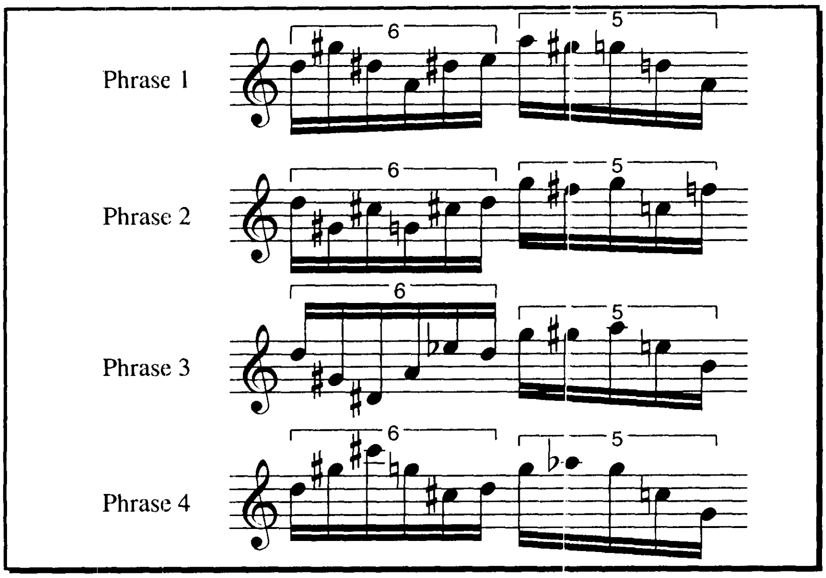
Phrase 3 - 2 1 1 5 2 5

Phrase 4 - 2 5 1 1 5 5

Phrase searching can also be undertaken using the *Phrase Garden* Mutation Mode. Such searching is undertaken in *CM* where the specific interval content of a phrase is known, yet variations are desired through the use of the either up or down interval direction setting. Specific phrase interval content in Variation Mode is not a possibility in *Phrase Garden* as the interval weightings used in this mode, from the outset of phrase generation, constantly present differing orders of interval content from one phrase to the next. The piano phrase in m.136 of the second movement of *CM* provides an example of a search using Mutation Mode. In this section of the work, the interval set 1 3 5 6 is used. The clarinet part in this section is predominant, the piano and marimba parts providing occasional accompaniment gestures. The clarinet part is generated using Variation Mode, in a manner that is detailed later in this chapter, with interval weightings, at m.137, favouring the intervals of 1, 5 and 6. The piano part is generated to provide a phrase that contains similar interval content to the clarinet part, yet is varied in the order of the content. The interval content is pre-defined for this measure as 6 5 5 6 1 5 1 1 5 5, with a Phrase Length setting of 11. Rhythmic material is also pre-defined, a 1/16th note sextuplet (mapped to interval 6) and a 1/16th note quintuplet (mapped to interval 5) reflecting the 1/8th note sextuplets and quintuplets in the clarinet part from mm.120-38. As the intervals 6 and 5 are mapped to rhythmic cells that provide 11 rhythmic values, and are the first intervals to appear in the interval series, the interval 1 need not be defined.

Figure 9.5 shows, in common notation, the phrases generated in Mutation Mode based on the pre-defined interval content. The %Mutation setting is set to 0%, enabling the generation of phrases that each have the same interval content in the same order, yet the resulting pitches vary with the use of the either up or down interval direction setting. Of the four phrases generated, each would suffice as a piano phrase in m.138. However, the second and fourth phrases, as they contain a C# pitch, were deemed more viable as this pitch is present in the clarinet material. The choice between the second and fourth phrases was arbitrary, each phrase presenting pitches of the clarinet part that the other did not, the fourth phrase finally chosen as the phrase used in the measure. In the fourth phrase of Figure 9.5, the second C# pitch appears as C#4. In the common notation score of *CM*, this pitch appears transposed down an octave (C#3), the transposition made in *Finale* during the editing stage of the work.

Figure 9.5 *CM,* Second movement, m.138, piano, possible phrases



The ability *Phrase Garden* offers to search through the genetic space of phrases is primarily used in *CM* where phrases are either required in one instrument part as accompaniment gestures to phrases previously generated and used in another part, or where a phrase is used as a focus within a sparse texture, such as in the initial clarinet and piano phrases of the first movement. Generally, however, pitch and rhythmic materials in *CM* are generated in multiple phrases. As shown in Figure 9.5, once the interval and rhythmic content of a phrase are defined, numerous consecutive phrases generated by the program are generally satisfactory. In *CM*, phrases generated were deemed satisfactory for a period of not just one phrase, but for a period of continuous phrases within a section of the composition.

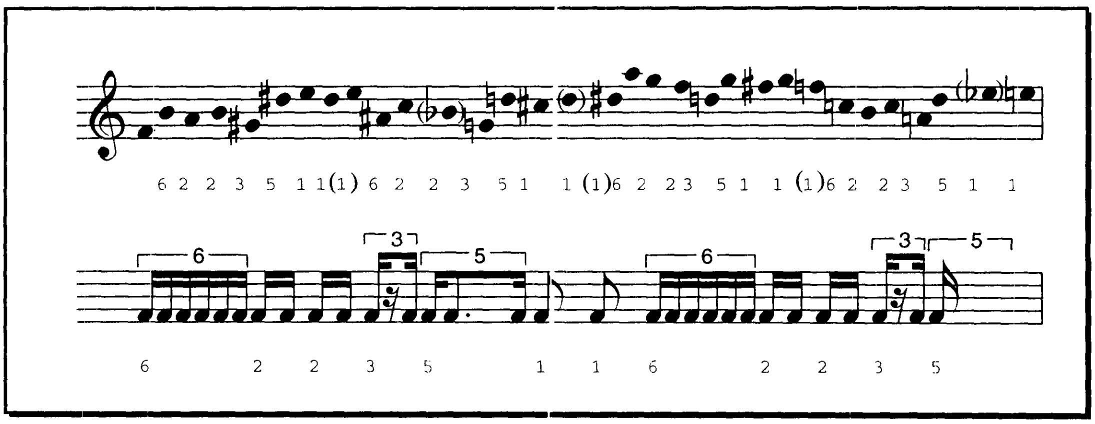
9.3.2. Phrases from Variation Mode

Two examples of the generation of multiple phrases in Variation Mode are used to show the manner in which the output of this mode is used in *CM*, one example from each of the first two movements. The right-hand piano phrases of mm.34-7 of the first movement provide the first example, in which a Phrase Length setting of 8 is used. Interval weightings are: interval 1 40%; interval 2 20%; interval 3 10%; interval 5 20%; and interval 6 10%. Interval direction settings are all 3, the either up or down direction setting, with a 50% probability of intervals ascending, and a 50% probability of intervals descending. The Phrase

Generate function was set to produce four phrases based on the same interval content (i.e. a parent, and three child phrases).

The interval content generated with the above settings is 6 2 2 3 5 1 1. Rhythmic mappings to these intervals are a 1/16th note sextuplet (mapped to interval 6), two 1/16th notes (interval 2), a 1/16th note triplet, the second value of which is a rest (interval 3), a 1/16th note quintuplet figure containing three rhythmic values, of which the second value is a dotted 1/8th note (interval 5), and a single 1/8th note (interval 1). The number of pitches generated over the four phrases is 32, whilst the number of rhythmic values is 18. This results in one complete statement of the rhythmic pattern, and one incomplete statement of the pattern that contains the first 14 rhythmic values. Figure 9.6 shows the resulting output, in common notation, of the pitch and rhythmic materials generated. The intervals generating each are shown below the staff, the bracketed interval denoting the interval generated in *Phrase Garden* which is a repetition of the final interval of the generated interval series, and provides the starting pitch of the phrase generated with the consecutive interval series.

Figure 9.6 *CM,* First movement, mm.34-7, piano right-hand interval content



A pitch range setting of F3 up to A4 is used, resulting in occasional interval leaps greater than six semitones. An example is the first D#4 of the pitch material, this pitch appearing seven semitones above the preceding G#3. In the generation of the pitch material, the D# would normally occur below the G#, as D#3, providing an interval of five semitones.

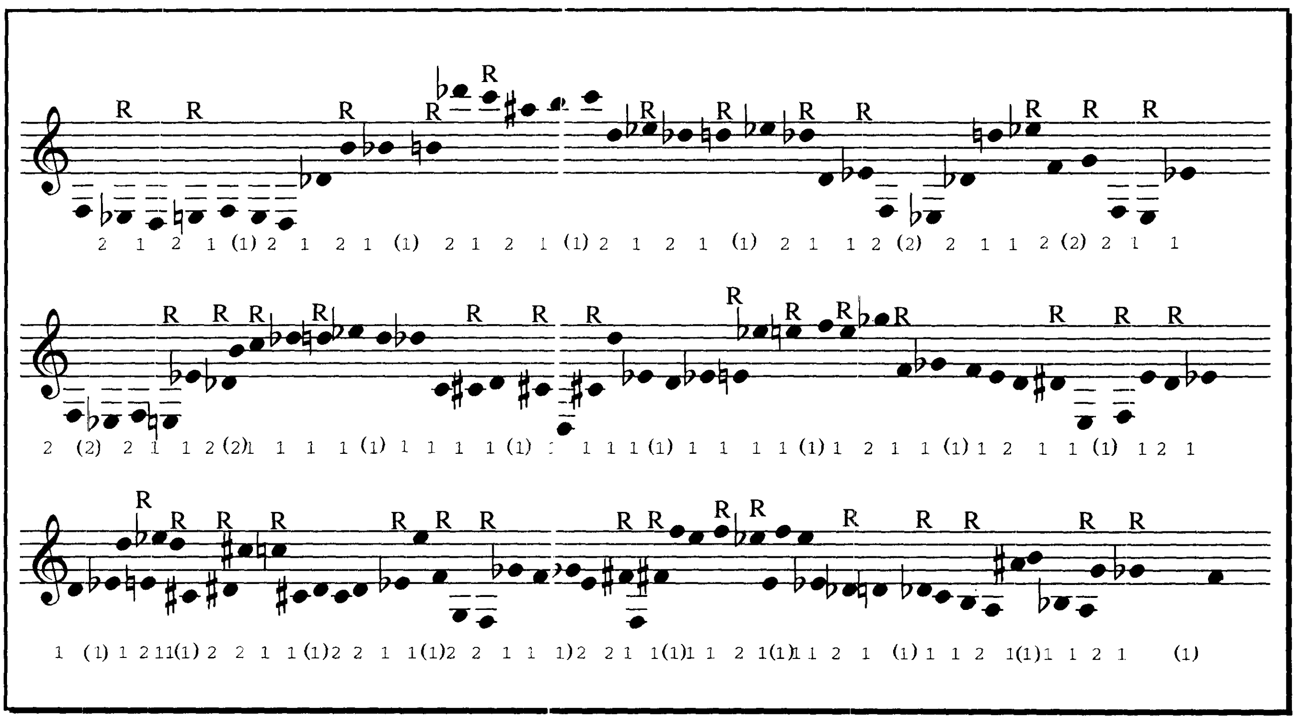
As the lowest pitch specified in the range is F3, the D#3 is transposed up an octave within the Pitch-range algorithm, to place it within the desired pitch range.

Notable in Figure 9.6 are the bracketed pitches that do not appear in the final version of the score. The first and last of the bracketed pitches are generated in *Phrase Garden*, but coincide with rests in the rhythmic material. Wherever rests occur in the *Phrase Garden* output, generated pitches that coincide with rests are skipped. In the mm.34-7 phrases, the rests are replaced, at the editing stage of the work, by single 1/8th notes that last for the duration of the first two 1/16th notes in the 1/16th note triplets in which the rests appear.

The second bracketed pitch in Figure 9.6 also does not appear in the final score. Again, this change was made at the editing stage of the work. The pitch was deleted, but the rhythmic value assigned to the pitch was retained. The effect of retaining the rhythmic value is that all pitches following the bracketed D are moved back a step, to have the rhythmic value of a previous pitch. This edit was made to provide a variation in the interval 1 steps produced in the *Phrase Garden* output. In the first occurrence of interval 1 (m.34) there is semitone movement between D#4 and E4. In m.36 there is semitone movement between F#4 and G4. Were the edit not made, similar interval movement would occur between C#4 and D4. With the deletion of the second D4, an interval of 2 occurs in m.35, providing a variation on the interval 1 movement that is desirable in comparison to the more repetitive interval 1 movement generated in *Phrase Garden*.

The second example of Variation Mode output in *CM* is from the clarinet part in the second movement at mm.1-22. This example is typical of the manner in which the majority of musical materials generated by *Phrase Garden* are used in *CM*. In the generation of such musical material, Variation Mode is used to produce not just a single set of parent and child phrases, as in the former example, but a series of parent/child phrase sets. With each new parent phrase, the set of interval weightings specified for use in Variation Mode will produce different orderings of intervals from an interval set. The interval set used in this section is 1 2, a weighting of 67% on interval 1 and a weighting of 33% on interval 2. Over the 22 measures, *Phrase Garden* generates six different orderings of the interval set 1 2, with a Phrase Length setting of 5. Each ordering, with a Phrase Generate setting of 1 to 4, produces four phrases, a parent and three child phrases in each case. The interval series generated for use in mm.1-22 section are: 2 1 2 1, 2 1 1 2, 1 1 1 1, 1 2 1 1, 2 2 1 1, 1 1 2 1. Figure 9.7 shows all pitch material generated for the section, each staff in the example corresponding to a clarinet staff in the full score. The intervals are shown beneath each staff. Following each statement of an interval series is the repetition of the final interval of the series, this interval, shown in brackets in Figure 9.7, providing the starting pitch of a consecutive phrase. The *Phrase Garden* Octave algorithm is also used in the generation of the mm.1-22 pitch material, with settings of 67% No Octave Transposition, and 33% 1 Octave, resulting in the periodic interval leaps throughout the example.

Figure 9.7 *CM,* Second movement, mm.1-22, *Phrase Garden* output without rests



In the rhythmic cells mapped to the intervals 1 and 2 in the mm.1-22 section, rests are used. The interval 1 is mapped to the final rhythmic cell for the interval 1 mappings shown in Figure 9.2 (1/16th note, 1/8th note rest, 1/16th note, 1/16th note triplet, 1/8th note rest). The interval 2 is mapped to the interval 2 cell containing a 1/4 note and a 1/4 note rest. In the *Phrase Garden* output, the presence of the rests in the rhythmic cells results in the replacement of corresponding pitch values with rest values. In Figure 9.7, the pitches that are replaced with rests are shown with the letter R above the staff.

The presence of the rests in the rhythmic cells used in the mm.1-22 section, along with the interval leaps provided by the Octave algorithm, results in a series of phrases that have the following characteristics: a high proportion of silence due to the rests; a rather unpredictable movement between registers of the clarinet due to the Octave algorithm; and little stepwise movement between pitches. In the final editing of the mm.1-22 clarinet part, many of the 1/4 note rests from the rhythmic cell mapped to the interval 1 were found to provide too much silence within the part. As a consequence, most of these rests were deleted from the part. Its unpredictable nature remains, however, with interval leaps, and with rests provided by the rhythmic cell mapped to the interval 2. The nature of the part serves to contribute to the programmatic portrayal of the character of the trickster.

9.3.3. Phrases from Mutation Mode

The Mutation Mode of *Phrase Garden* is used exclusively for the generation of pitch and rhythmic materials in the third movement of *CM*. A single example of the use of Mutation Mode is presented here, from the clarinet part in mm.73-88. This section is also programmatically concerned with the character of the trickster and, therefore, initial interval content specified for development in Mutation Mode is derived from the interval set 2 3 4 from the second movement, with the addition, in the third movement, of the interval 1. The initial order of this interval set in the clarinet part is specified in *Phrase Garden* as 2 3 4 1, with a Phrase Length setting of 5. Interval directions are all set to the either up or down direction setting. The Phrase Generate control is set as 1 to 1, in effect producing parent phrases, but no child phrases that would be based on the same interval content as the parent. The %Mutation control is set to 100%, generally resulting in all intervals in each phrase being altered by a semitone step in each consecutive phrase. An Interval Range setting of 0 to 7 semitones is used.

Over the 16 measures of the section there are 16 different five-note phrases used, the interval contents of which are shown at the top of Figure 9.8. The pitches produced by the interval sets are also shown in the Figure, a setting of 20% 1 Octave in the Octave algorithm resulting in the periodic wide interval leaps. As in Variation Mode, the final interval of each interval set generated in Mutation Mode is repeated to determine the starting pitch of each consecutive phrase. These are shown in brackets.

Figure 9.8 *CM,* Third movement, mm.73-88, interval content and *Phrase Garden* output

Rhythmic mappings used in the mm.73-88 section are shown in Figure 9.9. With the Phrase Generate control set to 1 to 1, each five-note phrase generated in *Phrase Garden* can only consist of five rhythmic values, and rhythmic cells containing more than five values cannot appear in their complete form in the section. The initial five note phrase consists of the intervals 2 3 4 1, and the rhythmic cells mapped to the first two intervals equate to five rhythmic values. The rhythmic cells mapped to the first two intervals match the number of pitches in the five-note phrase and appear in their complete form, and as such, the rhythmic cells mapped to the last two intervals do not appear.

In phrases such as the third phrase (2 5 4 0), in which the first two intervals present more than five rhythmic values, the second rhythmic cell will be incomplete. The rhythmic values for this phrase consist of the complete cell mapped to the interval 2, and three of the five 1/16th note quintuplet values in an incomplete cell mapped to the interval 5. In Figure 9.10 all of the rhythmic cells generated for the mm.73-88 section are shown. Where an incomplete rhythmic cell is generated it is marked with the letter I.

Figure 9.9 *CM,* Third movement, mm.73-88, interval to rhythmic cell mappings

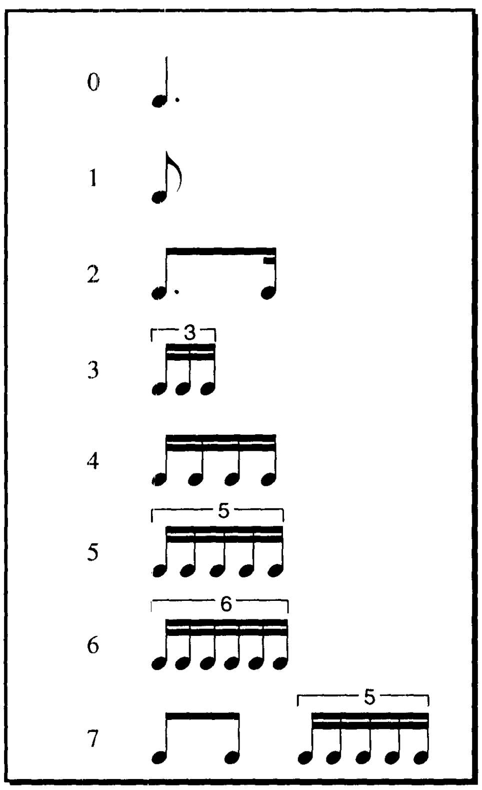
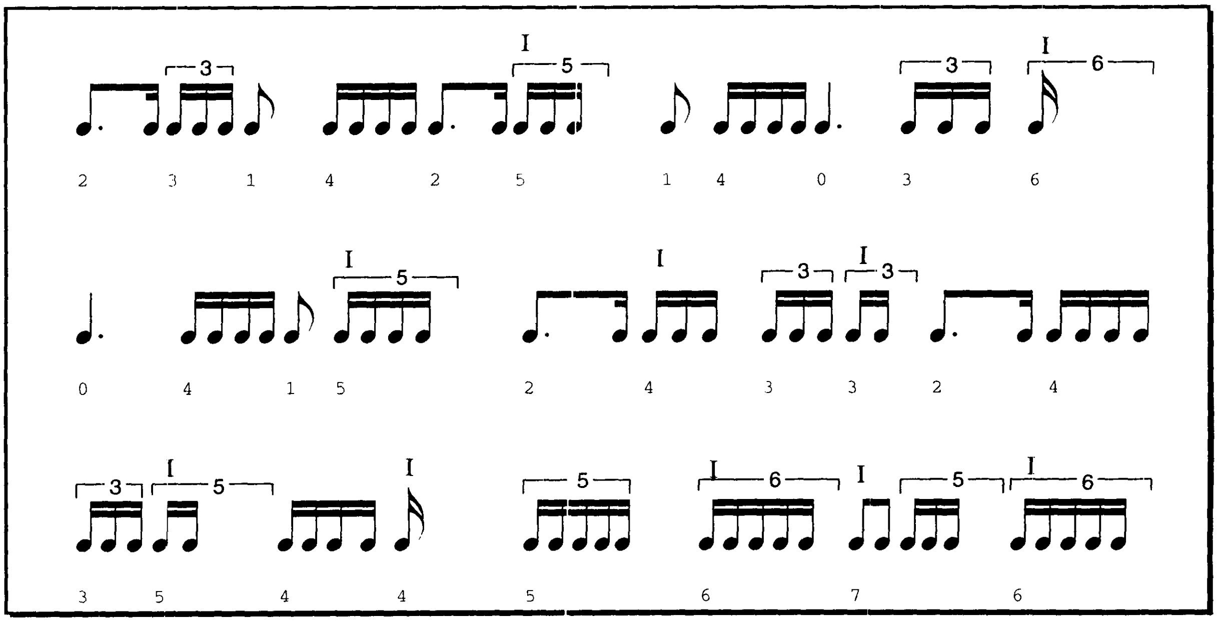


Figure 9.10 *CM,* Third movement, mm.73-8, generated rhythmic cells



In the editing stage of the work, the incomplete rhythmic cells are altered to result in logical sequences of rhythmic cells for a common notation based performance. As an example, the first incomplete cell in Figure 9.2, containing three 1/16th note quintuplet values, is altered to contain three triplet 1/16th note values. Notable in a comparison of the rhythmic values in Figure 9.10 and the rhythmic values presented in the final full score are alterations to the rhythmic cell mapped to the interval 1. The interval 1 rhythmic mapping is generally altered to be not a single 1/8th note, but a 1/16th note followed by a 1/16th note rest. This alteration was made primarily to provide breath space for the clarinettist.

As previously stated, Mutation Mode is used for the generation of pitch and rhythmic materials throughout the third movement of *CM*. The former example, associated with the character of the trickster, uses the Phrase Generate setting of 1 to 1 to provide continual semitone alterations in interval series from one five-note phrase to the next. Such alterations contribute to the programmatic portrayal of the unpredictable trickster character. Phrase Generate settings other than 1 to 1 are also used for the generation of pitch and rhythmic materials in the movement, such settings used where the programmatic content of the work calls for a more consistent iteration of interval series.

Mm.17-34 of the marimba part, programmatically associated with the melancholy of Cinderella, provide an example. Here, a Phrase Generate setting of 1 to 4 is used, while the Phrase Length, as in the former example, is set to 5. Rhythmic cells with long rhythmic values are used in a programmatic association with the melancholy of Cinderella, and an initial phrase interval content of 1 2 3 5 is specified. In the editing stage of the work, phrases generated by *Phrase Garden* for this section are separated by periods of one to three rest measures which allows the playing of untuned percussion instruments by the percussionist. The combination of the Phrase Generate setting with the long rhythmic values, and the expansion of the part with rest measures, results in the four phrases, a parent and three child phrases, based on the interval series 1 2 3 5. These four phrases occupy 16 measures of the movement, after which a new parent phrase is generated in Mutation Mode with the interval series 2 2 3 5. This is in contrast to the rapid changes in interval series presented in the former example associated with the trickster character, and suits the mood of melancholy depicted in the section.

In the context of the overall programmatic content of the work, the third movement represents a departure from the former two movements. In the first two movements the programmatic human character traits are explored through the use of Variation Mode. This mode, in varying the interval content associated with a character trait, allows the representation of different facets of the character trait. In the third movement, the use of Mutation Mode, in altering the intervals associated with the character traits, represents a lack of control by the character traits over Cinderella, this control given over to Cinderella who, in accepting and acknowledging the effects of the traits on her own character, is able to manipulate the traits to her own benefit.

As discussed in Chapter Eight, the manner in which Mutation Mode generates pitch and rhythmic materials represents a departure from the compositional style. In *CM*, phrases in the first two movements, in which Variation Mode is used to generate pitch and rhythmic materials, are similar to phrases in works such as *Tears and Coloured Diamonds*, composed with the compositional style. In both, groups of phrases in any one section have a consistency in their interval content. Phrases in the third movement of *CM* share many of the characteristics of phrases composed with the compositional style, characteristics such as wide interval leaps, and the use of rhythmic cells, however the underlying interval content is markedly different as there is little consistency in interval content from one set of parent/child phrases to the next. In *CM*, the use of Mutation Mode was used primarily to reflect the programmatic content of the work, as discussed above. However, Mutation Mode in general represents a method of expanding the compositional style, used either in its own right, as it is in the third movement of *CM*, or as a method of transition from one set of phrases that are consistent in their interval content to the next. Figure 9.11 shows a possibility wherein four parent phrases, based on the *CM* interval set associated with beauty, are generated with Variation Mode, are subject to a rapid transition in Mutation Mode over four phrases. The resulting interval set, based on the *CM* interval set associated with the trickster, is used for another four parent phrases in Variation Mode. To lengthen the overall process without altering interval content, sets of parent/child phrases would be used (i.e. a setting greater than 1 to 1 would be used in the Phrase Generate control).

Figure 9.11 Mutation Mode intervals in transition from/to Variation Mode intervals

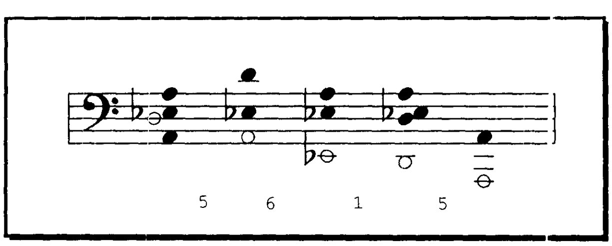
Variation Mode:	Phrase 1	1 2 5 1
	Phrase 2	1 5 2 1
	Phrase 3	1 5 1 2
	Phrase 4	1 2 1 5
Mutation Mode:	Phrase 1	1 2 1 5
	Phrase 2	0 1 2 6
	Phrase 3	1 2 3 5
	Phrase 4	2 3 2 4
Variation Mode:	Phrase 1	2 3 2 4
	Phrase 2	3 2 2 4
	Phrase 3	3 4 2 2
	Phrase 4	4 2 3 2

9.3.4. Vertical aggregates

In keeping with the lack of emphasis on vertical aggregates in the compositional style, vertical aggregates in *CM* are generally derived from the predominantly single line pitch materials generated for phrases, and added in the editing stage of the work. However, in *CM*, there are three points in the work in which chordal movement is predominant. At these points, *Phrase Garden's* Vertical aggregates algorithm (p chords) is used in the generation of pitch material. They occur in the second movement at mm.22-8, and mm.105-14, and in the third movement at mm.133-9, these sections of the work all programmatically portraying the character of the demon. The second movement section at mm.105-14 here serves to illustrate the manner in which the *Phrase Garden* Vertical aggregates algorithm is applied to generate pitch materials for the section.

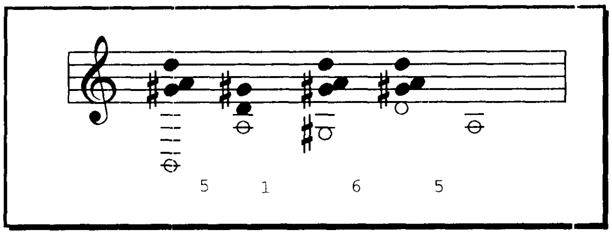
Intervals used in the second movement mm.105-14 section are from the interval set 1 3 5 6 (programmatically associated with the character of the demon) and are defined in Variation Mode as interval 1 (25%), interval 5 (50%) and interval 6 (25%). The interval 3 is not defined for the section. Interval directions are all set to the either up or down interval direction setting. A Phrase Length setting of 5 is used, and rhythmic mappings are limited to 1/4 note values only, the rhythmic values altered to suit the section in the editing stage of the work. In the p chords sub-patch, a Chord Density setting of 11 is used, providing 11 added pitches to the five single-line pitches generated with the Phrase Length setting. The Transposition setting control is set to 12, transposing each added pitch upward by an octave, and chords are enabled for the first phrase only. A seed pitch of D2 is used in all parts, where C3 is middle C. In Figure 9.12, the piano part generated with these settings is shown, and contains the interval series 5 6 1 5, these intervals occurring between the original, single-line, pitches that are shown in the Figure in open note-heads. The 11 added pitches are shown in black note-heads, the combined content of original and added pitches forming the vertical aggregates used in the mm.105-14 section.

Figure 9.12 *CM*, Second movement, mm.105-14, piano part vertical aggregates



For the generation of the marimba part in mm.105-14, the same settings were used as those used to generate the piano part; however, the initial single-line phrase generated in *Phrase Garden* for the marimba part has a different interval series from the piano part. The series generated for the marimba part is 5 1 6 5, the original single-line pitches generated by this series shown in Figure 9.13, again in open note-heads, and the 11 added pitches shown in black note-heads.

Figure 9.13 *CM,* Second movement, mm.105-14, marimba part vertical aggregates



In both the marimba and piano parts, minor editing of the vertical aggregates was intuitively carried out in the editing stage of the work. In the piano part, a D3 pitch was added to the fourth chord of the section, while in the marimba part, various pitches were subjected to octave transpositions.

The clarinet part in mm.105-114 is also generated with the same settings as the marimba and piano parts, with the exception of the use of the settings in the Vertical aggregates algorithm. The generated interval content for the clarinet part is the same as that in the marimba part (5 1 6 5). However, the use of the either up or down interval direction setting results in a differing set of pitches: D2 A2 Bb2 E3 A2. The clarinet part mimics the chordal texture of the other parts through the extension of the clarinet part with flutter tonguing, trilling and tremolo.

9.4. Editing

Following the generation of each *CM* phrase, or group of phrases, in *Phrase Garden*, the generated material for each part was saved in MIDI files within the p output sub-patch and subsequently transported across to *Finale* notation software. In *Finale*, the individual parts were combined into a full score format, edits such as those mentioned in the previous discussion of the applications of *Phrase Garden* algorithms were carried out, dynamics and extra-musical markings added, and phrase marks, not necessarily reflecting the phrase lengths generated in *Phrase Garden*, were added. The untuned percussion part was, throughout the work, also added at the editing stage. Such edits are viewed as small-scale edits, however there were also a number of large-scale edits carried out, in which the materials generated in *Phrase Garden* were dramatically altered, usually to provide continuity in the work where materials generated by *Phrase Garden* were generally acceptable, but were found to be lacking in some aspect.

An example of a large-scale edit occurs in the second movement at mm.141-62. On combination of the three instrument parts of the section in *Finale*, the section was found to be too long to sustain the intensity provided by three rhythmically active parts playing at a loud dynamic level. At the editing stage, short sections of the generated material, approximately one to two measures in length, were removed from all three parts. Figure 9.14, as an example, shows a portion of the generated interval content of the clarinet part, the first three parent/child sets, containing four phrases each, are shown. The intervals shown in bold are those that do not occur in the final score, a result of the removal of two measures of the generated pitch material at the editing stage.

Figure 9.14 *CM,* Second movement, from m.141, clarinet generated interval content and removed intervals

Parent/child set 1:	
	3 4 3 2
	3 4 3 2
	3 4 3 2
	3 4 3 2
Parent/child set 2:	
	3 2 4 3
	3 2 4 3
	3 2 4 3
	3 2 4 3
Parent/child set 3:	
	4 2 3 3
	4 2 3 3
	4 2 3 3
	4 2 3 3

Pitch and rhythmic materials were also added to the work at the editing stage. An example of such an addition is in the clarinet part in the third movement at mm.88-89. As previously discussed, *Phrase Garden* is used to generate 16 phrases in Mutation Mode for the clarinet in the section starting at m.73. The marimba part in the section is similarly generated, but the incorporation of untuned percussion results in a lengthening of the marimba part with rests, so that the marimba part finishes after the clarinet part. To address this lack of clarinet material, an intuitively composed measure is added to the end of the clarinet part (m.89), the ascending pitch material of the clarinet providing a contrast to the descending pitch material of the marimba.

The success of *Phrase Garden's* output is dependant upon the initial specification by the composer of the interval and rhythmic materials the program will use. If these specifications are true to the composer's intent, *Phrase Garden's* output will be from the genetic space of phrases related to the composer's selected materials, and the program will present the composer with phrases that will, in general, be satisfactory. However, materials generated for *CM* in *Phrase Garden* are not seen as an ultimate end product, but rather as a basis for the development of sections within the work. With such a view, editing of pitch and rhythmic materials generated is not seen as detrimental to the work. Rather, editing is freely used to enhance the materials presented by *Phrase Garden* so that desired musical outcomes are attained, along with a satisfactory portrayal of the programmatic content of the work.

9.5. Summary

In the development of *CM*, algorithms in *Phrase Garden* proved to be successful in generating pitch and rhythmic materials that were generally satisfactory in comparison to pitch and rhythmic materials developed within the compositional style. *Phrase Garden's* Variation Mode, in providing control over intervals used within a phrase, the direction of those intervals, and the weighting each interval receives, enabled the generation of series of phrases that could be searched to find a suitable phrase for a particular point in *CM*. Series of phrases generated in Variation Mode also proved to be viable for use in *CM*, and were used extensively as series of consecutive phrases within the work.

Phrase Garden, with its Mutation Mode, provided an alternative method of structuring pitch and rhythmic material, that, in combination with algorithms such as the Octave algorithm, enabled the development of pitch and rhythmic materials that were similar in nature to those of the compositional style, yet the underlying interval structures generating those materials were dissimilar to interval structures used in the compositional style. This alternative method of generating phrases, though it represents a departure from the compositional style, proved to be highly satisfactory in the generation of phrases for *CM*, and was used extensively in the third movement of the work.

With regard to the programmatic content of the work, phrases generated in Variation Mode proved to be most viable in the exploration of the characters and character traits portrayed in the first two movements of *CM*. The variations to interval structures provided by Variation Mode were associated with the exploration of different facets of the characters and character traits. Phrases generated in Mutation Mode, with their semitone shifts in interval content, proved to be viable for the programmatic representations with which the third movement of *CM* is concerned.

PART FIVE

CHAPTER 10 — CONCLUSION

10.1. Introduction

This chapter firstly presents a review of the areas examined in each of the four preceding parts of the study. Secondly, a discussion is presented concerning the use of commercially available automated composition programs, this discussion drawing on experiences gained from the use of such programs examined within the study. Thirdly, future possibilities concerning the use of artificial evolution for the generation of music are considered. The final section of the chapter presents a brief overview of each area documented in the study.

10.2. Review

Within the community of computer music composers, algorithms are initially introduced as practical solutions to problems encountered by composer/computer programmers, or are developed in order for the composer to explore musical possibilities of algorithms based on scientific or mathematical principles. The algorithms developed are drawn from a wide range of mathematical and scientific processes, resulting in five main algorithm categories: stochastic; rule-based; chaos-based; grammar-based; and Artificial Intelligence-based. With the development of fast personal computing platforms, algorithms from these categories have been incorporated in commercially available automated composition software programs, such as *M*, *Jam Factory* and *Symbolic Composer*. Both *M* and *Jam Factory* are non-development programs, in which the user does not have access to the underlying programming code, but may take advantage of a range of algorithms supplied in the programs. *Symbolic Composer* and *MAX,* alternatively, are development programs in which the user may develop his or her own algorithms. In this study, *Symbolic Composer* is used as a non-development program, to illustrate a wide variety of algorithms supplied within the program, whilst *MAX* is used as a platform for the development of new algorithms.

As discussed in Part One of the study, the applications of algorithms are extensively documented in relation to compositions by composer/programmers, however there is a paucity of examinations pertaining to the applications of commercially available algorithms by composers using such software. This study, in Part Two, has attempted to address this lack of literature by providing examinations of algorithms in the contexts of the three example works composed with the commercially available software programs of *M*, *Jam Factory* and *Symbolic Composer*. The study has also demonstrated the applications of a wide range of algorithms available in commercial composition software programs, and a variety of contexts in which the applications of these algorithms can occur.

Part Three of the study has provided brief analyses of works composed without computer assistance to reveal a personal compositional style. This style is used to show the manner in which the independent use of either *M*, *Jam Factory* or *Symbolic Composer* is not possible in wholly automating techniques of the compositional style. For such an automation of the compositional style a new program is developed, using the algorithm development capabilities of the *MAX* program. With the *MAX* program, a middle-ground in the composer/programmer paradigm occurs, this program presenting to composers the ability to assemble algorithms in a visually based programming environment, without the need to learn traditional programming languages such as C or LISP.

In Part Four of the study, inherent growth in the development of pitch and rhythmic materials of the compositional style is noted, and forms the basis of a search for a biological model on which to base the development of the automation of the compositional style. The field of A-Life is used as a starting point in this search, and the *Blind Watchmaker* program of Richard Dawkins is deemed viable as a model. As discussed in Chapter Eight, *Blind Watchmaker* begins evolution with an archetypal embryology in which a recursive branching rule influences the development of two-dimensional drawings on the computer screen. In a music program based on *Blind Watchmaker*, a musical archetypal embryology can represent a set of rules for generating notes of the compositional style note matrices, rules for weightings on one or more intervals, or rules for generating rhythms based on the numeric matrices. As the composer has the ability to define precisely rules for the development of musical structures, such an embryology, or rule set, will result in musical output that is representative of the composer's desires.

As detailed in Chapter Eight, *Blind Watchmaker* is used as a model in the development, using the commercially available *MAX* program, of *Phrase Garden.* In *Phrase Garden*, techniques of the compositional style are successfully automated, the program, as demonstrated, capable of presenting musical phrases that are generally of a similar nature to those developed in the compositional style. In the development of *Phrase Garden*, a departure from the Dawkins model was made to facilitate a closer representation of techniques used in the compositional style. This departure entails the variation, in *Phrase Garden's* Variation Mode, of interval orderings in sets of musical intervals that occur from one generation to the next. Mutations in this mode only occur as a by-product of a random procedure controlling the ascending or descending directions an interval takes in the production of a pitch. Using the Dawkins model accurately, mutation must occur in the interval values themselves, and to this end *Phrase Garden* implements another mode labelled Mutation Mode, in which intervals are altered from one interval set to the next through semitone steps. Phrases produced in this mode are unlike phrases developed in the compositional style in that there may be continual change in interval structures from one phrase to the next in the phrases produced by the program, while in the phrases developed in the compositional style, interval content from one phrase to the next is generally consistent.

As shown in Chapter Eight, *Phrase Garden*'s Variation Mode may be used to develop phrases that are similar in nature to those used in the compositional style, and the program in this mode is generally successful in automating techniques of the compositional style. Mutation Mode presents a way of extending the pre-existing compositional style through the generation of interval structures that are unlike those used in the compositional style. In combination with Mutation Mode, the *Phrase Garden* Octave algorithm, with the possibility of settings that result in interval leaps characteristic of the compositional style, provides similar interval leaps to those of the compositional style, while the underlying interval structure is dissimilar.

The example work composed with *Phrase Garden* and detailed in Chapter Nine illustrates the successful nature of the program in automating the techniques of the compositional style. Variation Mode is used successfully to develop single phrases, and series of phrases, in both the first and second movements, these phrases deemed to be highly satisfactory in relation to the general nature of phrases developed in the compositional style. Mutation Mode is used to develop series of phrases throughout the third movement, and whilst these phrases are based on interval structures dissimilar to those of the compositional style, they are highly suited to the portrayal of the programmatic content of the movement.

The satisfactory nature of phrases produced by *Phrase Garden* in relation to those developed in the compositional style is primarily dependant on the ability the program offers to search through the genetic space of phrases based on interval genotypes. If a specified interval genotype is truly representative of the composer's desires, then in general, the output of *Phrase Garden* will also be in accordance with the composer's desires. However, as shown in Chapters Eight and Nine, *Phrase Garden* may generate numerous phrases prior to generating a phrase that is representative of the composers requirements. Where such phrases are generated, they can be discarded and the generative process continued, though the ability of the program to present the composer with numerous phrases based on the one interval genotype can be advantageous in that the program can often present phrases that the composer might not ordinarily conceive. As discussed in Chapter Nine, the output of *Phrase Garden* may not entirely suit the composer's needs, and where this is the case, the output may be used as a basis of a section in a composition, and then edited within a MIDI sequencer or notation program.

10.3. Discussion

As shown in Chapters Four to Six, the composition algorithms available in the commercial programs of *M*, *Jam Factory* and *Symbolic Composer* generate musical structures that can form compositions, or sections of compositions, in their own right. This is, in general, without a need to resort to the incorporation of further structures developed either by hand, or with algorithms from other composition programs in order to present a completed composition. However, as discussed in Chapter Seven, when there is a pre-existing compositional style imposed on the desired outcomes of the commercially available programs, none of the three programs used in this study, in its entirety, is completely compatible with the compositional style.

For the composer without computer programming experience, two solutions to this incompatibility problem are possible. The first, as shown in this study, is to take advantage of the availability of commercially available algorithm development programs such as *MAX*, in which the composer may develop algorithms suited to his or her own compositional style, without the need to learn a traditional computer programming language.

The second solution entails the composer's use of a collection of commercially available automated composition programs with which the composer may take advantage of a wide range of algorithms. As shown in this study, not one of the composition programs examined is used to develop a composition from start to finish: for the *Etude in Memoriam Allan Dagg*, the output of *Jam Factory* is edited and compiled in a separate MIDI sequencing program; for *The Study for Triangles*, *Finale* notation software is used to develop acoustic parts for live performance interaction with the parts provided in *M*; and for both *Descendant Lines* and *CM*, *Finale* is used to edit, at times extensively, the output of *Symbolic Composer* and *Phrase Garden*. In combination, however, these programs offer the composer a wide range of algorithms that can be used to suit the composer's compositional style. As a simple example, a Markov process may form the basis of a composer's style in the area of vertical aggregates, in which case a program such as *Jam Factory* that offers Markov processes, can be used to generate such materials. A grammar-based algorithm in *Symbolic Composer* may be used to generate pitch and rhythmic materials. The output of the individual programs may then be combined in a MIDI sequencer or notation program.

The follwing comparitive charts provide a summary of the algorithms used within the software programs detailed in this study. The algorithms are divided into the main classifications previously detailed (with the exception of Artificial Intelligence-based algorithms) and the evolution-based algorithms provided with *Phrase Garden* are also included. Table 10.1 shows the algorithms that apply to the generation of pitch structures, and Table 10.2 shows algorithms that apply to rhythmic structures. Blank space within the tables indicate that there is no algorithm available in a program to suit an algorithm classification.

Table 10.1 Pitch algorithms, comparative chart

	M	Jam Factory	Symbolic Composer	Phrase Garden
Stochastic	Note-Order	Markov Chains	`gen-random`	Mutation Mode
Deterministic	Note-Order		`gen-fibonacci`	

Chaos-based			`gen-noise-brownian`
			`gen-hopalong`
			`gen-lorenz`	

Grammar-based			`gen-notrans` `gen-rewrite`	
Evolution-based				Mutation Mode Variation Mode

Table 10.2 Rhythm algorithms, comparative chart

	M	Jam Factory	Symbolic Composer	Phrase Garden
Stochastic	Note-Density	Markov Chains Silences	`gen-random`	Mutation Mode
Deterministic	Note-Density		`gen-fibonacci`	Variation Mode

Chaos-based			`gen-noise-brownian`
			`gen-hopalong`
			`gen-lorenz`	

Grammar-based			`gen-notrans` `gen-rewrite`	
Evolution-based				

With the range of algorithms provided in commercially available composition programs, the composer is generally assured of being able to find the necessary tools for the development of compositions that are closely aligned to the composer's personal compositional style. The range of available algorithms also enables the composer to extend his or her own compositional style through the exploration of mathematic or scientific processes used as the basis of algorithms in commercially available programs, processes that may not ordinarily be encountered without the use of commercially available programs.

In the instances where the composer's collection of commercially available composition programs fails to offer suitable algorithms for one or more aspects of the automation of a personal compositional style, a development program such as *MAX* can be used to develop algorithms suited to the composer's style. As shown in Chapters Eight and Nine, this approach can result in the development of further algorithms, such as those of *Phrase Garden's* Mutation Mode, with which the composer's personal compositional style can be successfully extended.

10.4. Future Possibilities

The discussion of *Phrase Garden* in this study has shown that artificial evolution is a powerful tool for the development of musical phrases based on a limited set of rules. By making an analogy between genes and intervals, and between phrases and phenotypes, the program offers the composer the ability to search the genetic space of phrases that share a single interval genotype, in order to find a phrase or series of phrases suited to a composition in progress.

Future work involving applications of artificial evolution to music may include the use of evolution in parameters other than those discussed in this study. Dynamic structures, harmony, and texture, for example, are all possible avenues for exploration. Future work may also include further exploration in the parameters of pitch and rhythmic structures. In the parameter of pitch, other methods of organisation could be explored, apart from that presented in this study which is based on interval content, methods such as the evolution of pitch class sets. In the parameter of rhythm, mutations of rhythmic values are possible with simple additive and subtractive processes as used by Dawkins in the *Blind Watchmaker*, for example a 1/16th note value may be subject to an addition of its own value, resulting in an 1/8th note, whilst a 1/4 note value may be subject to a subtraction of 75% of its value, resulting in a 1/16th note. The child rhythm of a parent rhythm containing the former of the two values will be markedly different from that of the parent, and just one in the genetic space of rhythms that are possible to explore using such rules for mutation in the production of child phenotypes.

The limitations set in this study on the exploration of key features of the compositional style with artificial evolution represent a starting point for future work. Numerous features of the compositional style not discussed in this study remain to be explored, for example weightings of consonance and dissonance within phrases, melodic contours (arch shapes, ascending or descending lines), rhythmic and melodic cadences, and texture. Each of these features, as demonstrated by Cope (1991), can be coded as data for computer manipulation. Such data may then be subject to replication and mutation within an artificial evolution environment. In exploring the concept of artificial evolution through key features of the compositional style, this study has provided a significant groundwork for the exploration of artificial evolution in further features of the compositional style.

10.5. Close

This study has shown possibilities of the applications of algorithms within commercially available automated composition programs, and has detailed the development of further algorithms where those in commercially available programs were found to be insufficient for the automation of composition techniques used in a personal compositional style. In the process, this study has:

1) attempted to address a paucity of examinations of algorithms in commercially available composition software through the use of such algorithms in the composition of three example works;
2) provided definitions of terms used in the field of automated composition, an overview of the history of automated composition, and overviews of four commercially available composition programs used in the field;
3) detailed a personal compositional style and incompatibilities in using commercially available algorithms in the automation of techniques of the compositional style;

4) shown possible models from the field of A-Life for the purposes of developing a new automated composition program suited to the compositional style; and

5) detailed the development of algorithms within a new automated composition program that addresses the incompatibilities between commercial algorithms and the automation of the techniques of the compositional style, and shown, with an example work, a way in which the compositional style is extended.

It is only in the past 15 years that commercially available programs have enabled composers with no experience in computer programming to use algorithms for automated composition. During that time the many algorithms available have been used by composers as tools within their craft, and have also offered composers a means of extending their compositional styles through the exploration of musical possibilities arising from the incorporation of algorithms based on scientific and mathematical principles. As shown in this study, there is a wealth of algorithms available to the composer, from which he or she may choose particular ones to suit his or her own compositional style. With new algorithms, such as those in *Phrase Garden*, being independently developed and made available through easily accessible and cost effective distribution such as Web sites, composers are free to choose algorithms for the generation of their works, algorithms that are suited to their own methods of working and provide possibilities of musical exploration.