

Bibliothèque nationale du Canada

Direction des acquisitions et

des services bibliographiques

Acquisitions and Bibliographic Services Branch

395 Wellington Street Ottawa, Ontario K1A 0N4 395, rue Wellington Ottawa (Ontario) K1A 0N4

Your file. Votre reference

Our file - Notre reference

NOTICE

AVIS

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments. La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

anada

Analysis of Cantico delle Creature

James Harley Faculty of Music McGill University, Montreal

February 1994

A Thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements of the degree of Doctor of Music.

© James Harley, 1994



National Library of Canada

Acquisitions and Bibliographic Services Branch Bibliothèque nationale du Canada

Direction des acquisitions et des services bibliographiques

395 Wellington Street Ottawa, Ontario K1A 0N4 395, rue Wellington Ottawa (Ontario) K1A 0N4

Your life - Votre reference

Our file Notre référence

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

L'auteur a accordé une licence irrévocable et non exclusive à la Bibliothèque permettant nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission. L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-94630-X



Abstract

This thesis presents an analysis of *Cantico delle Creature*, a composition for mezzo-soprano solo, chamber choir, chamber orchestra, and computer-generated sounds. The choir and orchestra are divided into two spatially separated groups, with the soloist and one percussionist (who plays the tam-tams, at the same time triggering the playback of the pre-synthesized sounds) providing a central link between the two ensembles. This work, which lasts approximately twenty-three minutes, sets a text of the same title by Saint Francis of Assisi. The analytical paper which accompanies the composition examines the text, the relation of the text to the form of the piece, the formal structure and textural organization of the music, the use of spatialization, along with the pitch organization and details regarding the creation and playback of the synthesized sounds. In addition, there is a discussion of the use of the computer as a compositional tool, in particular the utilization of CHAOTICS, compositional software based on nonlinear or "chaotic" functions designed by the author, for the creation of this work.

Résumé

Cette thèse présente une analyse de *Cantico delle Creature*, une oeuvre pour mezzo-soprano solo, choeur de chambre, orchestre de chambre et sons générés par ordinateur. La disposition spatiale sépare le choeur et l'orchestre en deux groupes distincts alors qu'au centre la soliste et un percussionniste (qui joue les tam-tams, en même temps qu'il déclenche le mécanisme de diffusion des sons synthétiques) assurent un lien entre les deux ensembles. Cette oeuvre, d'une durée approximative de vingt-trois minutes, met en musique un texte de St-François d'Assise. L'analyse qui l'accompagne examine le texte et sa relation avec la forme de l'oeuvre de même que la structure formelle et l'organisation des hauteurs et les mécanismes reliés à la création et à la diffusion des sons synthétiques. De plus, l'analyse traite de l'emploi de l'ordinateur comme outil compositionnel dans l'élaboration de l'oeuvre, en particulier l'utilisation de CHAOTICS, un logiciel compositionnel basé sur des fonctions nonlinéaires, ou "chaotiques," conçu par l'auteur.

Table of Contents

Introduction		1
Spatialization	•••••	2
Text		5
Formal outline	•••••	8
CHAOTICS	•••••	11
Pitch organization	•••••	17
Computer-generated sounds	••••	23
Detailed sectional analysis		26
Conclusion	•••••	43
Acknowledgements		44
Bibliography	••••	45
Appendix I: Text and translation	•••••	47
Appendix II: List of works by the author composed using CHAOTICS	•••••	49
Appendix III: Pitch collections	•••••	51
Appendix IV: Data for the computer-generated sounds	*********	64

Introduction

This paper presents a discussion of the composition *Cantico delle Creature*, written at McGill University in partial fulfillment of the requirements for the degree of Doctor of Music. The piece sets a text of the same title by Saint Francis of Assisi, and is written for mezzo-soprano solo, chamber choir (SATB divided into two groups), chamber orchestra (29 musicians divided into two groups of 14 players each, with one central percussionist), and computer-generated sounds.

The original impulse for the piece came from a visit to Assisi in September 1987, as part of a pilgimage to Rome in the company of Sister Elia Maciejewska, of a Polish order of Franciscan Sisters¹, to whom the piece is dedicated, in part. The spirit of St. Francis is still strongly felt in Assisi, 800 years after his life there, and it is that spirit (or at least what it has meant for me), together with the sounds of the hand-bells and church-bells which resound throughout the cobblestone streets of the beautiful town of Assisi (and the spirit of the Creator which can be sensed through those sounds and that landscape), that I wanted to try to convey through the music.

This analysis will touch on a number of aspects of the composition, from an explanation of the use of spatialization to the influence of the text, to discussions of the pitch content and overall structure of the work. In addition, the use of the computer as a compositional aid will be outlined, and details regarding the synthesized sounds will also be given.

While not intended to be exhaustive, this paper has been written to illuminate a number of the most important factors which have been brought to bear on the composition of this work.

¹The Order of Franciscan Sisters, Servants of the Cross, founded by Elzbieta Czacka and based in Laskikoła-Warszawy. The Order also has houses in Warsaw, other locations in Poland, and in Assisi.

Spatialization

The choir and orchestra used in *Cantico delle Creature* have been divided into two choral-ensemble groups (designated in the score and throughout this paper as Group A and Group B). The two groups are treated stereophonically, but in a particular way, which could be considered a form of heterophony. In other words, the musical material for each group is independent, but derives from a single underlying formal structure, and which together produce a unified composite texture, extended in space². The general placement of the performers is given in the diagram below:



²The soloist and the single percussionist who plays the tam-tams are placed in the center of the performance area. Their role is to bridge the gap, both spatially and musically, between the two groups. The tam-tams articulate the underlying structure of the work, while the mezzo-soprano draws on material from both Group A and Group B.

There are two main reasons for the use of a stereophonic spatialization in this piece. The first has to do with human perceptual abilities. Psychoacoustic experiments have shown that complex auditory signals can be more successfully perceived if those signals are spatialized in some fashion (cf. Bregman, 1990). In addition, Henry Brant, throughout his long career as a composer of spatialized instrumental works, has carried out many musical experiments on the various aspects of spatial distributions of acoustic sounds. His empirical observations confirm that music which contains complex textural or contrapuntal structures is much more clearly perceived if the performers are distributed in some fashion around or throughout the performance space (cf. Brant, 1967)³. Indeed, it has been my own experience, particularly in the electroacoustic domain, that spatialization can be a powerful compositional tool. In my computergenerated work for 4-channel tape, Voyage (1986), I conceived of the music as two strands of related, but in many ways distinct, material. These two strands were mixed into two separate stereo channels, and are meant to be projected out of loudspeakers on either side of the listener. It is only in the live performance of the tape that the two strands of music interact. This is quite a different approach to spatialization than the more common "panning" techniques used in electroacoustic studios, but the results are fascinating. The spatial interaction is not deceptive, or "virtual," as is the case with "panning" techniques. The spatialization of the music is live, not "pre-mixed," taking place right inside the "perceptual auditory space" of the listener, and creating, in a sense, a new and transcendent musical space.

Cantico delle Creature, then, attempts to extend this electroacoustic experience into the domain of acoustic sounds⁴. The music is similarly conceived as two parallel strands of material, related, but independently structured. The projection of the music in

³A detailed survey of the acoustical, theoretical and perceptual bases for spatialization in music, as well as a discussion of specific works by a number of composers who have utilized spatial distributions of performers can be found in (M. Harley, 1993).

⁴It should be noted that I have utilized spatial distributions of performers in previous works: Bells of Light (1982) for four choirs, Reflections on a Prayer of St. Augustine (1987) for nine choirs, and Memories of a Landscape (1988) for string ensemble.

performance will be much more complex spatially (given the number and variety of musicians, their distribution in the performance space, and the cross-audience projection of the computer-generated sounds coming out of the loudspeakers), but I am convinced, and the music has been composed to this end, that a similar enhancement or enrichment of the perceptual space will result.

The second reason for including spatialization as an important element of the piece is more poetic, and has to do with the "mystery" that permeates the canticle by St. Francis. As Carlo Carretto puts it, speaking in the person of Francis:

I felt myself to be steeped in God, as I was steeped in e erything I touched and everything I saw. Everything was one ... there was no denying God, not even if all things had been reassumed into the mystery of his Person, forever transcending the universe that contained it. ... The Mystery was space spread out round me by God out of respect for my littleness and my freedom. It was the half-light of that sublime alcove where All and Nothing meet to embrace, forever to deepen their knowledge of each other, and to unveil themselves to each other ...

(Carretto, 1982, 70-71)

St. Francis expresses this spiritual "space" in his poem, and it seems appropriate that the music which sets this text should also attempt to evoke the transcendent mystery of "All and Nothing" through the spatialization of the performers and through a stereophonic as well as heterophonic conception of the musical materials.

Text

5

Cantico delle Creature takes as its text the canticle-poem of the same title by Saint Francis of Assisi. This poem, completed in 1225, was written in the Umbrian dialect spoken in and around Assisi at that time⁵. It is one of the most well-known writings by St. Francis to have survived, and has been set to music many times, though rarely in the original language (the most common translations have been into Latin and Italian)⁶. In writing this poem, St. Francis was influenced by the the Canticle of the Three Young Men from the Book of Daniel (III, 52-90) in the Old Testament, which has been incorporated into the Roman Catholic liturgy⁷.

Saint Francis of Assisi

St. Francis, perhaps the most well-known of all Christian saints, lived from 1182 to 1226. As a young man who had been living a comfortable life as the son of a successful merchant in Assisi, Francis experienced, while recuperating from a serious illness, a powerful call to follow the way of Jesus. He took this conversion experience very seriously, giving up everything (his possessions, family, social standing in the community, etc.) in order to live as Jesus did. His devotion, charisma, and love for everyone and everything attracted disciples, and eventually led to the establishment of the Order of Franciscan Brothers, still active throughout the world today⁸. St. Francis

⁵Judging by the written text, the Umbrian dialect is closely related to modern Italian. Given that it is nearly impossible to know with precision how the language would have been spoken back in the 13th-century, the text has been treated in this piece as having the same syllabic stresses and pronunciation as present-day Italian.

⁶For a comprehensive catalogue of the compositions based on this text, and others by St. Francis, see (Poirier, 1980).

⁷Stockhausen incorporated this Old Testament text into his electroacoustic composition, Gesang der Jünglinge.

⁸There are numerous biographies of St. Francis, the most highly regarded being that of Paul Sabatier (Sabatier, 1941). Many of the stories and legends about St. Francis are collected in *The Little Flowers of St. Francis* (Francis, 1985).

wrote a number of prayers and poems, and in them all, and particularly in the *Cantico delle Creature*, he poured out his profound love for God, for God's people, and for all of God's creation.

Cantico delle Creature: the poem

The canticle by St. Francis is written in eleven short verses. Nine of these verses begin with the refrain, "Laudato si', mi' Signore" ("All praise be yours, my Lord")⁹. In a style similar to the Canticle in the Book of Daniel, each verse goes on to celebrate one aspect of creation¹⁰. St. Francis personalizes each of the "creatures" he is praising God for, a more direct way of expressing his love for all of nature (love being a personal, reciprocal act between "beings" rather than toward "things"), which for him was a means of expressing his love for the Person responsible for all of creation. Carlos Carretto, himself a monk, writes of this sense of "creature" as used in the canticle, speaking here in the person of St. Francis:

It has never been an effort for me to think of creatures, all creatures, as messengers of God, as signs from him. ... Creatures are God's 'tokens'. They contain his presence. They contain it, they live it, they express it with crystal chastity, without owning it. These 'things', creatures, have the power gradually to lead us to contemplation which, as it requires our commitment, is known as 'acquired' contemplation, and is the fountain of great joy.

(Carretto, 1982, 69-70)

The eleven verses of the canticle can be grouped into three sections, according to subject-matter. The first two verses offer praise to God in an unconditional way and at the same time establish the relationship between the all-powerful and the mortal ("All

The English translation of the original text has been provided by Carlo Carretto (Carretto, 1982: 144-145).

¹⁰An extract from Daniel, III clearly shows the relation between the two texts: All things the Lord has made, bless the Lord; give glory and eternal praise to him. Sun and moon! bless the Lord; give glory and eternal praise to him. English translation taken from *The Jerusalem Bible* (Jones, 1968).

praise be yours, all glory, all honour ... no mortal lips are worthy to pronounce your name"). The next six verses give praise for the various "creatures" of nature (Brother Sun, Sister Moon, Brother Wind, Sister Water, Brother Fire, Sister Earth). These verses can be further analysed into two sub-groups, the celestial bodies (sun, moon), and the elements (wind, water, fire, earth). The last three verses are more purely spiritual, grouping the "creature" Sister Death with the traits of forgiveness, humility and thanksgiving¹¹.

This analysis of the text brings to light a certain progression which carries through the poem: an opening celebration of the "most high, all-powerful" Lord; praise for the various facets of creation; and finally, the embracement of what could be called the Virtues or "Beatitudes"¹², including the acceptance of death¹³. This progression, and the subdivision of the canticle into three parts, has been used to shape the overall form of the musical composition, to be discussed below.

[&]quot;The full text, along with the English translation, is given in Appendix I.

¹²"Blessed are the poor in spirit, theirs is the kingdom of heaven..." From Jesus's Sermon on the Mount, Matthew V, 3-10 (*The Jerusalem Bible*, Jones, 1968).

¹³A more comprehensive discussion of *Cantico delle Creature* can be found in (Valle, 1926).

Formal Outline

The general form of *Cantico delle Creature* follows the verse structure of the poem by St. Francis. As mentioned in the discussion on the text, the poem can be grouped into three parts, as outlined below:

Part I	Part II	Part III
Verses I-II	Verses III-VIII	Verses IX-XI

The music also follows this plan, with the addition of a Prologue at the beginning, an Epilogue at the end, and transitional Interludes (which are instrumental, i.e., do not include voices) between the three large sections. In addition, there has been a third short Interlude added between Verses X and XI as a structural prolongation leading to the final verse-section and the concluding "Amen" and Epilogue. As well, a number of other short instrumental transitions between verses have been included (these will be discussed in the chapter on "detailed sectional analysis") The diagram which follows shows the overall formal structure of the piece, and gives the durations of the sections as well as cumulative durations of higher-level groupings.

							22:42	2							
	3:35					12:31	[6:36	5	
:43	2:	52	:53	3 4:22 6:33 :43 5:16			6:33 :43				1:20				
	1:27	1:25		2:20	2:02	2:08	1:37	1:57	:51		1:30	1:24	:41	1:41	
Prolo	gue Verso l	- 1 1 1	nterlude	5. 5 1 112		**************************************	Å 	Aii 5 5	×. Vili	Ц	LX LX	N. Samera	s. W	XI	Epilogu

As can be seen from the diagram, *Cantico delle Creature* is conceived on the largest scale in three movements, which are performed continuously. Each of these "movements" can be further subdivided, first of all into instrumental sections (e.g. the Prologue, Interludes, and Epilogue¹⁴), and vocal sections (i.e. where the voices are treated as the primary focus of attention) which set the text of the canticle by St. Francis (with an additional textual division occuring between Verses IV and V, and with the Interlude between Verses X and XI not considered a structurally independent section). Each of the large vocal sections can then be further subdivided into verse-sections (in which one verse of the text is heard). Musically, the beginning of each verse-section marks a change in texture (although there are often elements in the texture which continue into the new section as well), and a change in pitch material (with a new central, or focal, pitch and a new pitch collection for each ensemble-group).

The three main subdivisions of the work (particularly in reference to the divisions of the text) also serve to delineate the general vocal textures used in the piece. The organization of these textures can be seen in the diagram below:

	Part I	Part II	Part III
	(Verses I-II)	(Verses III-VIII)	(Verses IX-XI)
mezzo solo:		primary	integrated
		E A	8

In Part I, the vocal material is set in a chorale texture. In Part II, the mezzo-soprano solo is treated as the main focus of the music, with the choirs providing harmonic and textural support for the soloist, with the material based exclusively on the textual refrain, "Laudato si', mi' Signore." Finally, in Part III, the solo voice and the choirs are

¹⁴The Epilogue can be subdivided into vocal and instrumental sub-sections, but given that the text ("Amen") does not come from the canticle by St. Francis, the section as a whole is considered here to function structurally as a counterpart to the opening instrumental Prologue. In addition, there is no articulation of this subdivision by the "bell-gongs" and tam-tams, which, as will be discussed later, are used to mark the occurrence of all other sub-sections.

combined into a single texture, although the mezzo line is often more elaborate than those of the choral parts (the exception being found in Verse XI, in which the soloist anchors the elaborately heterophonic texture of the choirs). The large-scale structuring of the vocal textures derives in a certain sense from the analysis of the text discussed earlier. The laudatory character of the first two verses is expressed by the chorale-like music for the two choirs, in conjunction with the instrumental orchestration of these harmonies along with the bell-like texture which continues from the Prologue. The main part of the canticle, Verses III to VIII, which sing praise to the various "creatures" of nature, is reserved for the mezzo-soprano, with the choirs supporting the lyrical solo line by repeating the "Laudato" refrain in the manner of a cantus firmus. The final three verses, which move to a more purely spiritual plane, are set in a more unified texture (indeed, Verse IX is virtually a cappella, to emphasize the change of orientation in the text), with the soloist and choral voices integrated in a chorale-like style, though one more variegated than that of Part I. The chorale texture is retained for the "Amen" of the Epilogue, supporting the formal, tonal and textural elements which move toward full closure.

The overall formal outline, along with the general textural and structural considerations which have gone into the organization of the piece have been given here. The chapter on "detailed sectional analysis" which follows later will give a more precise account as to the musical organization of the work.

CHAOTICS

The composition of *Cantico delle Creature* has been carried out with the use of a computer program called CHAOTICS¹⁵. In brief, the computer program is used to generate data and translate that data into values which can be used compositionally. The generative process is based on a nonlinear function, which is a type of mathematical equation that, when applied recursively, exhibits complex behaviour, chaotic but at the same time ordered¹⁶. The most musically attractive feature of nonlinear functions is the principle of self-similarity, which carries through from the local all the way to the most global levels. At the same time, the output of the function remains to a certain extent unpredictable from one moment to the next. In a similar way, music is often understood in hierarchical terms, and much music theory and analysis is based on the similarities and relationships between the levels of this hierarchy. At the same time, many details at the surface level of the music remain unpredictable or unforeseen.

Cantico delle Creature is a large multi-faceted musical work. Underneath all the various elements of the composition, the structural organization, the textures, the textualmusical relationships, the spatialization, a central, generative source was deemed to be necessary and desirable. This underlying unity is also reflected in the text of St. Francis, and could be characterized there as an all-encompassing devotion to God. The selfsimilar, or auto-correlational, nature of the nonlinear function used in CHAOTICS seemed to lend itself to the task of providing a conceptual, as well as a material, source of unity for the piece.

¹⁵For a more detailed description of CHAOTICS, along with a more in-depth discussion of nonlinear systems or "chaos" theory, see (Harley, 1990). An overview of the domain of algorithmic composition is given in (J. Harley, 1993).

¹⁶I first came across nonlinear chaos theory in 1988 in an article on "strange attractors" by Douglas Hofstadter (Hofstadter,1985). Experiments with my programmable calculator convinced me (before discovering that many composers had already been attracted by the self-similarity of chaotic functions and fractal patterns) that such processes could be fruitfully applied to composition. A list of the compositions I have written which make use of CHAOTICS is given in Appendix II. More extended discussions of chaos (though still for the non-specialist) can be found in (Gleick, 1987), and (Stewart, 1989).

Program Modules and Architecture

There are four basic module-types in CHAOTICS. The first is the "generator," which produces numerical data from the output of a reiterative nonlinear function. The second is a "mapping" module, which scales the output of the "generator" to a particular range of values. The application of these values to some compositional purpose must be defined by the user. A large number of these mapping modules are set up, each connected to its own generator. The third module-type evaluates the statistical distribution of the values within the range set for the mapping module (over an arbitrary number of iterations of the function). This provides information about the behavioural characteristics of the data-generator. This module is then used in conjunction with the fourth module-type, which reorders values within the range specified by the mapping module on the basis of the distribution information. This reordering function is very important in that it allows the user a great deal of control over the process of translating the numerical data into musical material. The autocorrelational characteristics of the generative function are preserved, but the output "space" is able to be defined in ways more suited to the compositional situation at hand.

Generative Process

The particular nonlinear function used in this work is known as the one-dimensional logistic difference function, and is given, in simplified fashion, below:

$output_x = constant * input[output_{x-1}] * (1 - input).$

The function is set up to operate recursively, so that the output of the equation is fed back into the equation to produce a continuous stream of values. The constant is set such that the output will always fall within a certain range (usually between 0 and 1). In addition, the value of the constant determines the chaotic behaviour of the function, behaviour which can range from completely deterministic to quite random. To demonstrate the scope of these possibilities, two settings of the constant are given, with the output scaled



over integers between 1 and 12:

a) constant = 0.89output (over 48): 1.12 2.1 3.11 4.5 5.12 6.1 7.11 8.4 9.12 10.1 11.11 12.5 13.12 14.1 15.11 16.4 17.12 18.1 19.11 20.5 21.12 22.1 23.11 24.4 28.5 25.12 26.1 27.11 29.12 30.1 31.11 32.4 39.11 40.4 33.12 34.1 35.11 36.5 37.12 38.1 41. 12 42. 1 43. 11 44. 5 45. 12 46. 1 47. 11 48. 4 statistical analysis: Values: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Iterations: | 250 | 0 | 0 | 125 | 125 | 0 | 0 | 0 | 0 | 0 | 250 | 250 | (over 1000) Ordering: 12,1,11 (250) - 4,5 (125) - 2,10,3,9,7,8,6 (0) b) constant = **0.9999** output (over 48): 1.12 4. 1 2. 1 3.1 5. 1 6. 2 7.5 8.12 9. 4 10.11 11. 7 12.12 13. 1 14. 1 15. 3 16. 7 17.12 18. 2 19. 5 20.12 21. 3 22. 9 23.10 24.9 25.10 26. 9 27.11 28. 6 29.12 30. 1 31. 1 32. 2 33. 5 34.11 35. 5 36.11 37. 5 38.12 39. 3 40. 9 41. 10 42. 9 43. 10 44. 9 45. 11 46. 6 47. 12 48. 1 statistical analysis: Values: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Iterations: | 169 | 80 | 60 | 67 | 59 | 48 | 57 | 55 | 59 | 77 | 81 | 188 | (over 1000)

Ordering: 12 (188) - 1 (169) - 11 (81) - 2 (80) - 10 (77) - 4 (67) - 3 (60) - 5,9 (59) - 7 (57) - 8 (55) - 6 (48)

If the output of the function using the first setting would be used to generate the notes of a melody, i.e., with each number directly assigned to a pitch of the chromatic scale, the pitch structure would be very repetitive, being formed from two closely related "phrases":

B-C-Bb-E,	B-C-Bb-Eb,
B-C-Bb-E,	B-C-Bb-Eb

The second setting would generate a more complex structure, although still with a certain degree of repetitiveness:

B-C-C-C-C-C#-E,	B-D#-A#-F#,	
B-C-C-D-F#,	В-С#-Е,	B-D-G#-A-G#-A-G#-Bb-F,
B-C-C-C#-E-A#-E-A#-E,		B-D-G#-A-G#-A-G#-Bb-F

By using the re-ordering module, these "phrases" could be defined on the basis of specific musical considerations (defined by the composer). For example, the values could be reassigned according to tonal relationships, such that the most frequent value would be the tonic, the next most frequenct value the dominant, etc. The "phrases" given above would then be transcribed into phrases such as the following:

- a) C-G-E-D, C-G-E-B...
- b) C-G-G-G-G-D-F# C-F-E-Bb...

It is also possible to generate rhythmic values from the sample data given above. Each number from 1 to 12 could be assigned a duration (perhaps from one 16th-note up to a dotted half-note, producing rhythmic patterns such as:



Simpler rhythmic structures could be produced by limiting the range of values, perhaps to 4 instead of 12. Temporal proportions could also be developed by mapping a certain subset or cycle of the output values (e.g.for the first sample, a cycle could be taken as the set of eight values which repeat over and over) onto a pre-determined duration. As an example, a cycle of eight values taken from the first setting of the constant has been

scaled over a total duration of two minutes:

25.3" (12) - 2.1" (1) - 23.2" (11) - 10.5" (5) - 25.3" (12) - 2.1" (1) - 23.2" (11) - 8.4" (4)

Such a set of durations could be used to create some kind of musical structure, to be determined by the composer. On the basis of these examples, it could be possible to establish relationships between different hierarchical levels in the music, from rhythmic details on a local level, to structural proportions on a formal level. However, such applications of the nonlinear generative function to music composition are not built into CHAOTICS. The modules are designed to be as simple and general as possible; it is the task of the composer-user to determine how the tools are to be used.

The setting of the constant for *Cantico delle Creature* was fixed at 0.9955, and kept the same for all compositional processes carried out with the aid of CHAOTICS. The statistical ordering (over 1000 iterations) for the function using this constant is given below, again with the output mapped onto integer values from 1 to 12:

Ordering: 12 (189) - 1 (131) - 11 (100) - 10 (91) - 9 (78) - 4 (71) - 6 (65) - 3 (62) - 5 (61) - 2 (59) - 7 (49) - 8 (44)

The generator module (in conjunction with the other modules), using the function given above with the constant set as indicated, has been used in this piece to provide material for a great deal of the music, from the durations of the large sections of the piece to the durations of the sub-sections to detailed rhythmic structures, from the progression of central pitches to the intervallic structure of the pitch collections to the surface melodic material. The data which is generated acts as a source of intervals or proportions, which can be drawn upon and applied to all types of musical parameters and structures. It should be pointed out, however, that all of these materials must be individually defined in such a way that the CHAOTICS modules can be set up to produce the desired results.

The aim, in making use of the compositional computer program CHAOTICS is not to present in music some sort of sonic representation of mathematical functions. Rather, the aim is to create a musically coherent work based on materials derived in part from

nonlinear chaos theory. It is not important that the chaotic characteristics (nonlinear, hierarchical self-similarity) of the music be directly perceived as such; however, these characteristics are intended to support the musical structure, to contribute to the work's formal constituency and originality. As was said above, underlying unity and structural consistency are important factors for the composition of such a large-scale work as the *Cantico delle Creature*.

Pitch Organization

The pitch organization for *Cantico delle Creature* is based on two main principles or techniques. The first is the use of a set of fixed-register pitch collections as the source of all the pitch material used in the piece. The second is the use of a sequence of central, or focal, pitches (also fixed in register) over the course of the work, to provide a sense of underlying tonal or harmonic continuity and progression.

Primary Pitch Collections

The fixed-register pitch collections (or mixed-interval, non-octaviating scales) upon which this piece is based, have been constructed within the pitch space from El to Bb7 (the lowest and highest octaves of the piano). There are thirteen collections for Group A, and thirteen related collections for Group B, one collection for each group being used in each of the eleven verse-sections of the piece, with a separate collection for the Prologue and the Epilogue (along with secondary pitch collections, to be discussed below). The Interludes are treated as transitions, and make use of the combined collections of the previous and following sections. Ascending from E1, the pitch collections are generated according to a selection process based on the nonlinear function described in the section on CHAOTICS. Four interval-classes (ICs) are used (1,2,3,4), and each IC is given a different statistical weighting (governing the likelihood of that particular IC being selected) for each collection. This weighting is inherent to the output of the generative nonlinear function; the re-assignment of statistical weights to particular ICs is carried out by means of the re-ordering module in CHAOTICS. The two collections for each section of the piece (one for group A, one for group B) are related in that they are given the same statistical weighting. There are twenty-four possible combinations for ordering a set of four intervals. In Cantico delle Creature, eight of these interval orderings are used, as indicated below:

1-2-3-4 (Vrs I)	2-1-3-4 (Prolog, Vrs VII)	3-1-2-4 (Vrs III, V, IX)	4-1-2-3 (Vrs XI)
1-2-4-3	2-1-4-3 (Vrs IV, X)	3-1-4-2	4-1-3-2
1-3-2-4 (Vrs VI, VIII)	2-3-1-4 (Vrs II)	3-2-1-4	4-2-1-3
1-3-4-2	. 2-3-4-1	3-2-4-1	4-2-3-1
1-4-2-3	2-4-1-3	3-4-1-2	4-3-1-2 (Epilog)
1-4-3-2	2-4-3-1	3-4-2-1	4-3-2-1

The limited use of the possible statistical orderings of the ICs is intended to help establish a sense of underlying unity in the intervallic organization of the music.

An example of specific data concerning one IC order actually used in the piece can be outlined as follow: if the ICs are ordered such that IC1 is most likely to occur, and IC4 is least likely to occur (order 1-2-3-4), and if 1000 intervals are generated using the same setting of the nonlinear function as has been used for *Cantico delle Creature* (constant = 0.9955), then the number of occurences of each IC can be summarized as follows:

IC	I	1	ł	2	I	3	1	4	1
Totals		380		252	1	197	1	171	

In this case, IC1 is 2.22 times more likely to occur than IC4. On the local level, the statistical weightings of each IC may be skewed, given that each pitch collection contains no more than 20-30 intervals. However, this generative process is used to produce the raw material from which the pitch collections can be constructed, allied with melodic, harmonic, and other compositional considerations. If the output of the function is taken directly, then a sample set of intervals can be constructed as follows, taking the pitch E3 as the starting point:

numerical output

1 2 2 2 1 3 1 3 1 4 1 3 pitch collection:



As shown in the example above, each pitch collection can be characterized as having differing interval structures in each register (i.e. they are non-octaviating). In some cases, there will be repetitions from one octave to another, but this is not generally the case. In addition, particular intervallic configurations give rise to sub-sets which may resemble diatonic sets, pentatonic sets, chromatic sets, etc. (all of the pitch collections used in the piece are given in Appendix III). Thus, a wide range of pitch material is available, and each section of the piece will, because of the particular pitch collection being used, have its own range of potential characteristics or colours to be drawn upon for its harmonic/melodic material.

In order to provide continuity from one section of the piece to another, there are always a number of common tones between one pitch collection and the next (for each ensemble-group). In addition, there are also a certain number of common tones between the pitch collections of Group A and Group B within each section, and these common tones are often given structural importance in the elaboration of the harmonic or melodic material for a particular section.

Secondary Pitches

In addition to the primary pitch collections discussed above, *Cantico delle Creature* also makes use of secondary pitch collections. The incentive for their inclusion was the desire to be able to make use of passing tones, neighbouring tones, and other ornamental tones in order to fill out melodic contours or textures, while at the same time avoiding indiscriminate use of diatonic or chromatic material (particularly given the specific nature of the pitch organization used for the piece). To that end, a second set of pitch collections was constructed, one collection for each of the two ensemble groups for each of the thirteen sections of the piece. The same statistical weighting governing the primary pitch collection for each section was used for the generation of the interval structure of each secondary collection. The two collections were then added together, and where the pitches of the secondary collection do not coincide with the primary collection, the additional pitches were then reserved for use as passing tones, or other ornamental

figures, as stated above¹⁷.

Central Pitches (fixed in register)

The idea of having a central, or focal, pitch for each section of the piece is to provide a sense of tonal, or harmonic, focus for each section, as well as to create a sense of underlying tonal/harmonic continuity over the course of the whole work. These central pitches have been chosen from within the range of the vocal registers, *E2* to *Bb5*, to enable the choirs to articulate them as required. The intention, then, has not been to compose a series of roots or fundamentals over which harmonies can be constructed. The centrality of these focal pitches refers not only to their structural importance or weight, but also to their general location in the middle of the pitch space used in the piece (again, it should be emphasized that these central pitches are fixed in register). The texture of the music is meant to radiate outward from the central pitches, at times above, at other times below, and at other times both above and below.

As can be seen in the figure below, where the central pitches for each section are given in musical notation, there are several notable features in this progression. Firstly, the pitches for the two ensemble-groups follow different paths for the most part, but there are three sections in which they share the same central pitch. Those structurally important sections are: the Prologue, which acts as an initiation into the sound-world of the piece; Verse X, which functions as the beginning of the third and final large-scale part of the work; and the Epilogue, which closes the piece. Secondly, there is an overall contour to the progression, which begins at the highest point of the pitch space within which the central pitches have been selected (Bb5), descends, ascends again, and finally descends to end in the low-middle register (G3). In addition, this progression also moves to the G at the end with a certain amount of tonal direction, in that the preceding five sections all contain central pitches which are diatonically related to the final pitch. In the

¹⁷In Appendix III, where the pitch collections are given, only those secondary pitches which differ from the pitches of the primary collection are shown, and these secondary pitches are not included in the analysis of the interval content.

context of the more harmonically complex or diffuse pitch collections for each section, this background harmonic progression is not likely be perceived with much force. Nevertheless, the underlying organization is intended to provide a certain sense of tonal/harmonic continuity and progression.

progression of Central Pitches:



The pitches which have been used as focal points for the work are collected below and ordered as to register:



It should also be noted that the computer-generated "bell-gong" sounds are designed to contain the central pitch for each section within the partial or overtone structure of each sound. This is to provide a harmonic link between the acoustic sounds and the sounds which are diffused through loudspeakers. The intention is that the sounds of the

two performing groups, along with the two channels of electroacoustic sounds, will fuse harmonically and timbrally within the environment of the performance space and through the perceptual faculties of the listener experiencing the music within that space.

Computer-generated sounds

The starting point for the sonic imagery of *Cantico delle Creature* was the memory of bells ringing through the streets and along the hillside in and around Assisi. In order to create a unique bell-sound, which could be used both to evoke a ritual-liturgical atmosphere as well as to provide the structural foundation for the work, a synthesized "bell-gong" sound has been combined with the timbre of large tam-tams. The computer-generated sounds, projected through loudspeakers surrounding the audience, are intended to resonate the performance space, in a complementary relationship with the complex acoustic signal coming from the tam-tams on-stage. In addition, the synthesized sounds are designed in such a way that they will be integrated into the harmonic organization of the piece.

As described above in the section on pitch organization, there is a progression of central, or focal pitches, which provide a harmonic foundation for the piece. The synthesized "bell-gong" sounds have also been included in this scheme. Each sound, formed by an additive process (i.e. a number of simple sounds, or "partials" are combined to form a more complex signal), contains, as one of its component "partials", the central pitch for that section of the piece in which the "bell-gong" sound is to be articulated. Using CHAOTICS, two processes were designed to determine the number of "partials" for each sound, and to designate the particular "partial" containing the frequency corresponding to the appropriate central, or focal, pitch (the detailed data is given in Appendix IV).

The partials, or overtones, of these "bell-gong" sounds have been designed to bear some relationship to, without being identical to, pure harmonics (related by integer). In a harmonic relationship, if the fundamental tone is 100 Hz, then the first overtone will be 200 Hz, the second 300Hz, and so on. For the sounds designed for *Cantico delle Creature*, if the lowest component of the sound is 100 Hz, then the next component would be selected from within the region of 150 Hz to 250 Hz. For practical reasons, the number of components was limited to a maximum of twenty-three (and a minumum of seven). An example of the frequencies of one of these sounds is given below:

Partial:	:	z)]	1	2 :	3	4	5	6	7	8	9	10
Freque	ncy (H		100	199 :	2 95	427	513	578	737	846	898	1029
	12	13	14	15	16	17	18	19	20	21	22	23
1157	1248	1302	1395	5 1488	1612	1786	1887	1963	2056	2160	2276	2354

It should be pointed out that it is the relationships between the partials that are important, as the frequencies for these components are calculated on the basis of the given central pitch, and which partial it has been assigned to. If for example, the frequency corresponding to the central pitch is 100 Hz, and the central pitch is assigned to the seventh partial, then the frequencies of the partials corresponding to the example given above would be:

Partia	1:		1	2	3	4	5	6	7	8	9	10
Frequ	ency ((Hz)	14	27	40	58	70	78	100	115	5 12	2 140
11 157	12 169	13 177	14 189	15 202	16 219	17 242	18 256	19 266	20 279	21 293	22 309	23 319

From these examples, it should be clear that a wide range of sounds can be produced on the basis of these processes (in terms of sound quality, the first set of partials would give a quasi-harmonic bell-like tone, while the second would give a lower, noisier, gong-like tone, given the appropriate dynamic envelopes). These sounds, though, will always be related by the central pitch/frequency, and the amplitudes of the partials within each sound are designed to always give prominence to whichever partial is assigned this primary frequency.

Performance set-up

Ideally, the computer-generated sounds (there are 106 of these "bell-gong" sounds, 53 for each channel) would be stored on a hard-disk or in a sampler, and would be triggered by the percussionist who performs the two tam-tams which are always heard in

conjunction with the synthesized sounds (one tam-tam for each channel of sound, each channel being associated structurally and harmonically with one of the two ensemblegroups). This could be done either by means of a MIDI foot-switch, or by converting an audio signal from the tam-tams into a MIDI signal which would then trigger the stored sound-file. The most efficient method of managing this process would be through a MAX program¹⁸, which could route the signal from the performer to the sound-file (and which would also contain functions to allow for back-tracking, resets, and so on-these are necessary for rehearsals and to allow the system to be controlled manually in case of problems during performance). It would also be useful to prepare a pre-recorded tape, which could be used in those performance situations where the required hardware would not be available. This would necessitate the creation of a click-track for the conductor, as the "bell-gong" sounds on the tape would have to be precisely coordinated with the tam-tams. This would be the least desirable of the two performance possibilities, given the inflexibility of tempo that would result.

¹⁸MAX is an Interactive Graphic Programming Environment designed for use with MIDI (Musical Instrument Digital Interface). Cf. Puckette & Zicarelli, 1990.

Detailed sectional analysis

As has been stated above, the computer generated "bell-gong" sounds, together with the live tam-tams, are used as structural indicators, to articulate the sub-sections of the piece. At the same time, this bell-like sound-complex sets the tone for the whole work, in the particular timbral and spatial texture which it creates, and in the ritual, liturgical atmosphere it evokes through experiential resonances of bells and gongs with religious services of various kinds and cultures, and through the consistency with which this sound is repeated all the way through the piece (although the computer-generated sounds are constantly changing in terms of frequency components and overtone structure, even as the general dynamic envelope stays the same). As will be seen below, the duration between attacks of these articulatory sounds gets longer and longer (by means of a nonlinear progression) as the piece progresses.

In light of what has already been described of the overall formal outline, this chapter will give an outline of each of the sixteen main sections of the piece, showing the durations of the sub-sections, and discussing those aspects of the music which seem most important for each particular section of the work.

Prologue

The piece begins with the "bell sound-complex" (synthesized sounds with tam-tams) alone. Then, with the articulation of each new sub-section (there are six sub-sections in the Prologue), additional bell-like sounds enter (pitched percussion instruments and the two keyboards, celeste and piano). The surface of the music is "arhythmic," giving the impression of a soft "cloud"¹⁹ of bell-like sounds, taking as their point of departure the central pitch *Bb5*, which is shared by both ensemble-groups. The articulation of the fifth sub-section by the synthesized and acoustic bell-like sounds is enhanced by the addition of brass and string timbres, the first non-percussive instruments to be heard. In this sub-

¹⁰"nuage"--used in the same sense that Xenakis uses this term (c.f. Xenakis, 1992).

section, the trumpets attack the central pitch, with the violins sustaining it softly, and in the final sub-section, this sustained part of the texture is filled out in order to introduce an eight-pitch chord beneath the *Bb5*, which leads (through voice-leading connections) to the first chord of the next section:



The durational structure of the Prologue is given in the diagram below:

60 beats @ ↓ = 84 (0:43)									
11	6	7	8	14	14	Ì			

Verse I

The five-pitch chord (given in the figure above) which begins this verse-section acts as a harmonic anchor (an expansion of the two central pitches, C5 and B3) for the entire section. There are seven sub-sections, each of which contains one word or short phrase

of text, sung by the choirs and set syllabically in chorale style. The anchor chord, rearticulated for each sub-section by staggered attacks in the brass (with clarinet), is used to start off each phrase of the choirs. The strings double the harmonies of the choirs, to provide reinforcement and to enhance the sustained quality of the chorale texture. At the same time, the "bell-cloud" texture created by the pitched percussion and keyboard instruments continues, carrying forward the atmosphere created in the Prologue, and unifying the three sections which make up Part I of the piece.

	122 beats @ ↓ = 84 (1:27)											
16	15	19	12	19	19	22						
l Altissimu	onnipotente	bon Signore	I Tue so' le laude	la gloria	l'honore	et onne benedictione						

Verse II

The chorale texture continues into Verse II (as does the bell texture, although the "cloud" gradually disperses over the course of the section), with a second anchor chord, a seven-pitch (five pitch-classes) chord derived from the new pitch collections associated with this verse-section:



The supporting instrumental texture is developed somewhat, with tremolo strings doubling the staggered attacks of the brass, and woodwinds sustaining the harmonies of the choral phrases. In addition, the strings begin to ornament the vocal lines, becoming more elaborate with each new sub-section. This soft, increasingly detailed contrapuntal string texture leads directly into the first Interlude, at the same time as the bell texture disappears and the sustained chorale texture finishes.

118 beats @ ↓ = 84 (1:25)								
10	25	13	15	10	20			
Ad te solo	Altissimo	se konfano	et nullo homo	ene dignu	te mentovare	ł		

Interlude I

This quiet passage acts as a transition from the rather jubilatory, full-textured Part I to the more chamber-like character of Part II, and at the same time serves to introduce the mezzo-soprano solo. The strings elaborate an eight-part linear structure which eventually arrives at the central pitches of Verse III, F2 and E4 (some of the lines continue into Verse III before reaching their goal pitches). The low pitch, F2, common to the pitch collections of both group A and B, is introduced by the timpani at the second sub-section of the Interlude. The crescendo into a strong articulation of the two central pitches by the brass at the beginning of Verse III marks the arrival of Part II of the overall form, and sets up the entrance of the solo voice.



Verse III

-

Verse III is made up of five sub-sections, the first four each setting a line of the text as a melodic phrase for the solo voice, and the last serving as a short instrumental transition to the next section. Each of the four main sub-sections is organized around a chord, with the two central pitches being continually sustained by the double-basses:



These harmonies are sustained by the choirs and the strings, who elaborate the chords, in a manner which continues the texture of Interlude I. In addition, the solo vocal melody is punctuated by fanfare-like figures in the trumpets and high woodwinds. Gradually, the woodwinds begin to play bright, ornamental figures in the upper register, which continue into the short transitional passage leading to Verse IV.

168 beats @] = 72 (2:20)							
35	40	32	44	17			
Laudato sio, mi' Signore,	cum tucte le tue creature.	specialmente messer lo frate sole, lo quale iorno et allumini noi per loi;	Et ellu è bellu e radiante cum grande splendore: de te, altissimo, porta significatione.	fransition			

Verse IV

The rapid figuration in the woodwinds which began in Verse III continue throughout Verse IV, while at the same time helping to sustain the harmonies which underpin this section, together with the female voices of the choirs and the lower strings. The "bright" character of the previous verse ("Brother Sun") evolves here into a "cold, starry" texture ("Sister Moon and the Stars"), characterized here by high harmonics in the upper strings, bowed cymbals, and sparsely-placed bell sounds in the mallet and keyboard instruments. Again, the vocal line is supported by a progression of harmonies, one for each syllable of the "Laudato si', mi' Signore" refrain, making this section slightly more active, in terms of harmonic motion, than the previous verse:



As in Verse III, the final sub-section acts as an instrumental transition, this time a little more extensive, to the next verse. The change in texture is more sharply contrasted here, to help delineate the formal grouping of Verses III to IV and Verses V through VIII (taken from the subject matter in the verses of the text).

č.,
	146 bea	ats @ ↓ = 72 (2:02)		
28	40	49	29	
I Laudato si', mi Signore,	I per sora luna e le stelle;	in celu l'ài formate clarite et pretiose et belle.	transition	1

Verse V

The transition between Verses IV and V provides a rather sudden shift to the material used in the next section. A short crescendo in the timpani leads to a strong articulation of C#3, the central pitch of Group A for Verse V. Fast ascending passages in the woodwinds and violas leading to trills which are doubled by the vibraphones and keyboards (supported timbrally by tremolos and glissandi in the high harmonics of the strings) set up the main textual image of this verse, "Brother Wind and the Air." The formal separation from the previous two verses is further emphasized by the powerful setting of the "Laudato" refrain in the choirs (without the solo voice) and brass. The mezzo-soprano comes in at the second sub-section, while the "wind" texture continues. In this verse, the choirs are silent after the opening refrain, and the middle-register harmonies which are used to provide support for the solo voice, are instead sustained softly by the brass (with bassoons). The flurries and trills of the "wind" texture gradually thin out, eventually to be taken over by falling arpeggios in the vibraphones and keyboards; this element is carried over into Verse VI. In addition, the high harmonics of the upper strings gradually descend until they blend into the sustained chorale texture of voices and strings which begins the next section.

	153 beats	@ 」=72 (2:08)
33	40	27	53
Laudate si', mi' Signore	e, per frate vento, et per aere	et nubilo et sereno et onne tempo,	per lo quale a le tue creature dai sustentamento.

Verse VI

In a similar way to Verse IV, this section is based on a harmonic progression, here consisting of nine chords rather than eight²⁰, heard in the first sub-section in a choralelike setting of the "Laudato" refrain (doubled by the strings), and then repeated in the next sub-section, without the choirs, with the strings and woodwinds that are supporting the mezzo-soprano:



²⁰The progression is made up of nine chords, but there are actually only five differenct chords in the sequence: 1-2-3-4-2-5-1-4-2.

Throughout that second sub-section, and the following one, which acts as a short instrumental transition to the next verse, the woodwinds gradually begin to ornament the sustained pitches with neighbour-tone trill figures (a musical response to the text, "Sister Water"), building up the texture and then continuing it right up to the start of Verse VII.



Verse VII

In Verse VII, the "water" texture (woodwind trills) changes to rapid rising figures each of which culminates in a sharp attack of a note which is then sustained. In the second sub-section, the accented note is doubled two octaves higher by the crotales or glockenspiel, and in the third sub-section, the it is coloured by the flute playing fluttertongue, and by a short crescendo *sul ponticello* in the violin. The density of these figures is increased right up until the final sub-section is reached (again a transitional passage to the next verse) when the "fire" texture is allowed to die away.

	110 beats @ ↓ = 72	2 / 25 beats @ 🕽 = 60 (1:57)
26	35	49	25
Laudato si', mi Signore,	per frate focu, per lo quale enallumini la nocte;	ed ello è bello et iocundo et robustoso et forte.	J = 60 transition

The underlying harmonic structure is quite simple, being an alternation of just two chords, sustained by the strings and the women's voices of the choirs, who sing the elongated syllables of the "Laudato" refrain. Supported by these harmonies, the solo voice, as is the case for virtually the entire middle part of the work (Verses III-VIII), sings a straightforwardly lyrical and expressive melody:



Verse VIII

The vocal components for Verse VIII are set up in a two-part structure (aside from the opening "Laudato" refrain, in which the solo voice is reinforced by the female voices in the choirs), with a long slow melody in the basses which serves as a counterpoint to the more florid line (though still predominantly syllabic) sung by the mezzo-soprano. The upper vocal line is supported by harmonies in the strings, while the winds articulate a rather dense texture in the low-middle register featuring complex cross-rhythms and *sfp* articulations. The cumulative rhythm of wind attacks is doubled by large tom-toms, and the dark timbre of the these drums, together with the bass voices of the choirs reinforced by the double-basses, has the effect of "grounding" the texture of this section (a musical image taken from "Sister Earth").

61 be	ats @	•
27	34	
Laudato si', mi' Signore, per sora nostra matre terra,	I la quale ne sustenta et governa, et produce diversi fructi con coloriti fiori et herba.	i

Beginning in the second sub-section, the violins commence playing long ascending melodies which are ornamented by means of neighbour-tone figures in the piano and celeste. This material continues into the following Interlude, finally descending again to reach the pitch A3, the central pitch in both ensemble-groups for Verse IX.

Interlude II

This section, which serves to articulate the formal division between Part II and Part III, basically continues a number of musical elements from Verse VIII. The complex texture of the wind instruments continues, although the low tom-toms shift to timpani, and follow their own simpler rhythmic structure. The rhythmic density increases over the course of this section, but at the same time, the range of pitches gradually contracts toward the shared central pitch of the next section. The double-basses, carrying on without the bass voices, are joined by the cellos in elaborating a kind of repeated-note ostinato alternating between two pitches, D3 and A3, finally settling, like the winds, violins and keyboards, on A3 at the beginning of Verse IX.

51 beats @ J = 72 (0:43) 51

Verse IX

The arrival of Verse IX marks a strong change in musical texture, to emphasize the beginning of the Part III. The music to this point has proceeded in a continuous fashion, with certain elements or layers of the material carried through from one section to another, to provide a sense of continuity and forward motion. The music does not stop at Verse IX, but after the bell/tarn-tarn articulation of the first sub-section, which is also the moment when all of the instruments arrive at *A3*, the central pitch of this verse-section, all of the instruments drop out except for the timpani, which softly sustain the central pitch. The *a cappella* passage which follows serves as a respite from the rather complex and detailed textures which have been heard up to that point. The choirs again sing in chorale style, with the solo mezzo-soprano echoing and elaborating the simple setting of the choirs. The strings provide harmonic links from the end of one sub-section to the beginning of the next. In the last sub-section, the strings continue through to the end of the phrase, rather than dropping out, acting as a timbral link to the next verse.



Verse X

The central pitches of this section, F5 and B4, are given a prominent orchestration throughout the passage, being continually articulated and sustained by a succession of wind instruments. The aim is to highlight the timbral colours of the orchestral

instruments (as a contrast to the *a cappella* setting of Verse IX), and to initiate the largescale cadential motion which carries through from this verse to the end of the piece (c.f. the discussion above on Pitch Organization). From the second sub-section, these sustained pitches are ornamented by neighbour-tone figures, and this more elaborate texture is carried through into Interlude III which follows. As for the vocal parts, the opening "Laudato" refrain is also based on the two central pitches (giving a tritone as the primary harmonic interval), though with some motion to neighbouring pitches to give shape to the overall phrase. However, for the rest of the section, the vocal parts are treated independently (in terms of harmonic organization), with the chorale texture of the choirs acting as a counterpoint to the more elaborate solo line.

101 beats @ J = 72 (1:24)										
49	52									
Laudato si', mi' Signore, per sora nostra morte corporale, de la quale nullu homo vivente po skappare:	quai acquelli ke morrano ne le peccata mortali; beati quelli ke trovarà ne le tue sanctissime voluntati, ka la morte secunda nol farrà male.									

Underpinning the voices and winds is a bass texture, which oscillates between the perfect fifth, G2-D3, and the octave, F#2-F#3, eventually settling on the octave before dropping out to allow the rising chords of the upper strings to take over. These five chords, given below, which lead into the next section, also provide the harmonic basis for the ornamented notes and chords of the mallet percussion instruments and the two keyboard instruments, which become more and more prominent, right through the short Interlude and into the final verse:



Interlude III

This short passage acts as an instrumental transition to the final verse-section, and as such is similar to other transitional passages discussed above. However, it is lengthier than any of the earlier ones, and so merits treatment as a separate section. The basic focus of this passage is the high string texture, based initially on the fifth chord of the progression given above. Having reached that high point, the strings, playing harmonics, begin to slowly descend, by means of overlapping glissandi and held-notes. Tied to the evolving harmonies in the strings, the bell-sounds (pitched percussion, keyboards) also begin to fall in pitch, and this general process continues right up to the Epilogue, ending with the arrival of the final focal pitch of the piece, G3. In addition, the winds, continuing their material from Verse X (sustained tones ornamented by neighbour-tone figures), also descend gradually, arriving at the beginning of Verse XI at the central pitches for that section (B4 and D4).



Verse XI

This final verse of the text, a summational "Laudate," is set in a rather elaborate way. The voices of the choirs, starting on the two central pitches of this section, B4 and D4, create a complex heterophonic texture, with each voice following its own melodic and rhythmic structure, rhythmically united only at the start of each word. In addition, each of these lines is elaborated, again heterophonically (i.e. with an independent rhythmic, and at times melodic, structure) by a wind instrument. Anchoring this complex texture is the solo voice, which articulates the text using only the two central pitches, and a very simple rhythmic structure. This role-change, whereby the soloist provides support for the intricate choral-instrumental texture, is also intended to add to the effect of closure, with the mezzo-soprano concluding her lyrical, flowing solo line with a simple declamation of the final verse of the text.



Epilogue

As stated in the discussion of Interlude III, the strings, together with the bell-sounds, continue to descend right through Verse XI, finally coming to rest at the beginning of this section, on the common central pitch, G3. The wind instruments that had been part of the heterophonic texture of the previous section, descend through the first part of the

Epilogue, arriving at the focal pitch, or tonic, just as the voices enter for the final "Amen."



This brief, static, closing passage affirms G (and G3 in particular) as a tonal center, as do the winds, sustaining the G3 very softly beyond the end of the choral phrase. At the same time, the strings, playing in harmonics, move up from that central pitch, to end on a high chord, which is intended to be a timbral extension of G3:



This sense of "tonality" which becomes prominent at the end of the work is important for two reasons. The first is that the harmonic organization of the piece, while quite complex, does contain an underlying "tonal" sense, as discussed in the chapter on Pitch Organization. The transpace icy with which this background structure is displayed in the

Epilogue (and in the three sections preceding it) is designed to establish a sense of closure powerful or direct enough to resolve the tensions and to brake the forward motion of the work as a whole. In addition, this tonal design reflects that of the poem. The final verse of the text acts as a kind of spiritual "tonal center," drawing together all the images of the poem and redirecting them toward the Creator.

Conclusion

Cantico delle Creature, a composition of some twenty-three minutes in duration, for mezzo-soprano solo, two choirs, two instrumental ensembles, and computer-generated sounds, is intended to pay tribute to the profound, yet colourfully poetic, spirituality of St. Francis of Assisi. Music, considered by some to be the most spiritual of art-forms, is at the same time highly sensuous. St. Francis, clearly one of the most saintly men in history, was also very much attracted to the "creaturely" beauties of the world. In this composition, an attempt has been made to create a work which encompasses something of both these aspects of St. Francis, particularly as expressed in his canticle. Bell sounds, both rich in timbre and in association, are prominent throughout the piece, and indeed, are used to mark the ongoing structure of the piece as it unfolds. Elaborate textures and expressive melodies are given a particular stereophonic spatial manifestation, to surround the listeners with richly detailed sounds, and to envelope them with a certain sense of mystery. The organization of the music is meant to support these aims.

This paper has been written to detail some of the processes which have gone into the composition of this piece, and to outline some of the background for the selection of the text, the impetus for composing the music, and the intellectual considerations which have contributed to the gestation and realization of the work. Much is left to be said, or perhaps cannot be said. What remains is the music. And if the work is successful, the music, and the poetic words of St. Francis, will sound out for themselves.

Acknowledgements

There are a number of people to thank for their help in completing this work. First of all, I must express my sincere gratitude to John Rea and Bruce Mather for admirably carrying out their duties as advisers through the long process of carrying out this thesis. I would also like to acknowledge Bruce Pennycook, for his advice on matters relating to the synthesis and play-back of the computer-generated sounds, for directing my Special Project in the domain of computer-aided composition, and for enabling me to take advantage of the computing resources at the Faculty of Music of McGill University.

During the preparation of this thesis, I received financial assistance from the Province of Québec (FCAR Doctoral Fellowship) and from the Canada Council (Project Grant), and for this important support I am grateful.

In addition, I would like to thank Stephanie Field for her interest in this project, and for her beautiful voice, which has served as a model for the writing of the solo part; Sister Elia Maciejewska, for finding the Umbrian text for me, and for all her prayers; Marco Parisotto, for his help with the pronunciation of the text; Lise Viens, for translating the abstract; and especially my wife Majka, for her editing skills and constructive criticism during the writing of this paper, her patience, her domestic support (when she had more important things to do), and, most importantly, for her love.

Bibliography

- Brant, Henry. "Space as an essential aspect of musical composition." In *Contemporary Composers on Contemporary Music*. eds. Elliott Schwartz & Barney Childs. Holt, Rinehard & Winston, New York, 1967.
- Bregman, Albert S. Auditory Scene Analysis: The Perceptual Organization of Sound. MIT Press, Cambridge, MA, 1990.
- Carretto, Carlos. I, Francis: The Spirit of St. Francis of Assisi. William Collins Sons, London, 1982.

Francis, of Assisi, Saint. Cantico delle Creature. 1225.

companions. tr. E.M. Blaiklock & A.C. Keys. Hodder and Stoughton, London, 1985.

Gleick, James. Chaos: Making a New Science. Penguin Books, New York, 1987.

Harley, James. "Chaos: musical applications." [unpublished paper] Faculty of Music, McGill University, Montreal, 1990.

-----. "On algorithmic processes in music composition." In *Proceedings of the LUTCHI Symposium on Creativity and Cognition*. Loughborough University of Technology, Loughborough, England, 1993.

Harley, Maria. "From point to sphere: spatial organization of sound in contemporary music (after 1950)." *Canadian University Music Review*, 13, 1993: pp. 123-144.

- Hofstadter, Douglas. "Mathematical chaos and strange attractors." In *Metamagical Themas: Questing for the Essence of Mind and Pattern.* Basic Books, New York, 1985: pp. 364-395.
- Jones, Alexander (General Editor). *The Jerusalem Bible*. Darton, Longman & Todd, London, 1968.
- Poirier, Léandre. Répertoire musical sur saint François d'Assise : pour aider à la célébration du VIIIe centenaire de sa naissance, 1182-1982. Extrait de Chroniques et documents Province Franciscaine Saint-Joseph du Canada. Vol. 33, no. 2, juillet 1980.
- Puckette, Miller & David Zicarelli. MAX: Development Package. Opcode Systems, Inc., Menlo Park, CA, 1990.

- Sabatier, Paul. Life of St. Francis of Assisi . tr. Louise Seymour Houghton. Hodder and Stoughton, London, 1941.
- Scotti, Tommaso Gallarati. "La vita di San Francesco." Supplemento al N.4 del 24 Gennaio dell' Illustrazione Italiana "San Francesco d'Assisi--Nel Settimo Centaenario Della Morte." 1926: pp. 2-14.
- Stewart, Ian. Does God Play Dice: The New Mathematics of Chaos. Penguin Books, London, 1989.
- Valle, Luigi. "Il 'Cantico del Sole'." Supplemento al N.4 del 24 Gennaio dell' Illustrazione Italiana "San Francesco d'Assisi--Nel Settimo Centaenario Della Morte." 1926: pp. 22-25.
- Xenakis, Iannis. Formalized music: thought and mathematics in composition. Rev. ed. Pendragon Press, Stuyvesant, NY, 1992.

Appendix I: Text and translation

CANTICO DELLE CREATURE

San Francesco d'Assisi (translation by Carlo Carretto)

I. Altissimu, onnipotente, bon Signore, Tue so' le laude, la gloria, l'honore et onne benedictione.

> Most high, all-powerful, good Lord, All praise be yours, all glory, all honour and all blessing.

II. Ad te solo, Altissimo, se konfano et nullo homo ene dignu te mentovare.

To you alone, Most High, do they belong. No mortal lips are worthy to pronounce your name.

 III. Laudato sie, mi' Signore, cum tucte le tue creature, specialmente messer lo frate sole, lo quale iorno et allumini noi per loi; Et ellu è bellu e radiante cum grande splendore: de te, altissimo, porta significatione.

> All praise be yours, my Lord, with all your creatures, Especially Sir Brother Sun, who brings the day; and light you give us through him. How beautiful is he, how radiant in his splendour! Of you, Most High, he is the token.

IV. Laudato si', mi' Signore, per sora luna e le stelle; in celu l'ài formate clarite et pretiose et belle.

All praise be yours, my Lord, for Sister Moon and the Stars; in the heavens you have made them, bright and precious and fair.

V. Laudato si', mi' Signore, per frate vento, et per aere et nubilo et sereno et onne tempo, per lo quale a le tue creature dai sustentamento.

All praise be yours, my Lord, for Brother Wind and the Air, and fair and stormy, all the weather's moods, by which you cherish all that you have made.

VI. Laudato si', mi' Signore, per sora aqua, la quale è multo utile et humile et pretiosa et casta.

All praise be yours, my Lord, for Sister Water, so useful, lowly, precious and pure.

VII. Laudato si', mi' Signore, per frate focu, per lo quale enallumini la nocte; ed ello è bello et iocundo et robustoso et forte.

> All praise be yours, my Lord, for Brother fire, through whom you brighten the night. How beautiful is he, how gay, robust and strong!

VIII. Laudato si', mi' Signore, per sora nostra matre terra, la quale ne sustenta et governa, et produce diversi fructi con coloriti fiori et herba.

All praise be yours, my Lord, for Sister Earth, our mother, who feeds us, rules us and produces various fruits with coloured flowers and herbs.

 IX. Laudato si', mi' Signore, per quelli ke perdonano per lo tuo amore, et sostengo' infirmitate et tribulatione; beati quelli kel sosterranno in pace, ka da te, Altissimo, sirano incoronati.

> All praise be yours, my Lord, for those who forgive for love of you and endure infirmity and tribulation.

> Happy are those who endure them in peace, for by you, Most High, they will be crowned.

 Laudato si', mi' Signore, per sora nostra morte corporale, da la quale nullu homo vivente po skappare:
guai acquelli ke morrano pe le peccata mortali: beati quelli ke trovarà ne le tue

guai acquelli ke morrano ne le peccata mortali; beati quelli ke trovarà ne le tue sanctissime voluntati, ka la morte secunda nol farrà male.

All praise be yours, my Lord, for sister Physical Death, from whose embrace no mortal can escape.

Woe to those who die in mortal sin! Happy are those she finds doing your most holy will! The second death can do no harm to them.

XI. Laudate et benedicete mi' Signore, et rengratiate et serviateli cum grande humilitate.

Praise and bless my Lord, and give him thanks, and serve him with great humility.

Appendix II: List of works by the author composed asing CHAOTICS

Variations (22 min.) for piano solo - 1989 (unfinished).

Piano (14 min.) for piano - 1989 premiere: Laurie Hartz, Western Washington University Alumni Composers Festival, Bellingham, USA, April 1989

Night-flowering ... not even sand - I (12 min.) for bassoon and tape - 1989 premiere: Johnny Reinhard, McGill Electronic Music Festival, Montreal, Quebec December 1990

Song for Nobody (8 min.) for solo clarinet - 1990 premiere: Rachel Ménard, GEMS, McGill University, Montreal, Quebec February 1991

Night-flowering ... not even sand - II (9 min.) for tape - 1990 premiere: GEMS, McGill University Montreal, Quebec September 1990

Ma'dhanah (12 min.) for solo accordion - 1990 premiere: Joseph Petric, Sound Symposium, St. John's, Newfoundland, July 1990

Neue Bilder (Der Hölle Rache) (9 min.) for chamber ensemble - 1990/91 award: 2nd prize, New Music Concerts "Mozart" Composition Contest premiere: New Music Concerts Ensemble, Robert Aitken - conductor, Toronto, Ontario, March 1992 Daring the Wilderness (11 min.) for percussion ensemble - 1991 premiere: McGill Percussion Ensemble, Pierre Béluse - conductor, Montreal, Quebec March 1991

Étude pour une Fête (Jazz II) (6 min.) for chamber ensemble - 1991 commission: Société de musique contemporaine du Québec premiere: Ensemble de la SMCQ, Véronique Lacroix - conductor, Montreal, Quebec, November 1991

Kekula (Memories of a Landscape - III) (15 min.) for orchestra -1992 premiere: Hamilton Philharmonic Orchestra, Victor Feldbrill - conductor, Hamilton, Ontario, May 1993

÷

Here the Bird (13 min.) for viola and piano - 1993 commission: Laura Wilcox and Brigitte Poulin premiere: Laura Wilcox & Brigitte Poulin, Ottawa, Ontario, January 1993

Wine of Dragons (7 min.) for Japanese drum group - 1993 commission: Arashi Daiko

Appendix III: Pitch collections

-square noteheads indicate pitches common to Collection A and Collection B.

-open notcheads indicate primary pitches.

-filled noteheads indicate secondary pitches.

-upward-pointing arrows indicate common pitches with the collection from the previous section.

-downward-pointing arrows indicate common pitches with the collection from the following section.

Prologue

Generative interval order (statistical weighting, from highest to lowest): 2-1-3-4 Analytical data for the pitch collections used (secondary pitches are not included):

IC	Ι	2	1	1	l	3	1	4		 	
A	1	12		10	l	8	ł	5	l		
В	1	9		6	l	7	I	8	l	 	
Total	 	21	 	16	 	15		13		 	

Pitch Collection A:

Central Pitch: Bb5



Pitch Collection B: Central Pitch: Bb5



Verse I

Generative interval order: 1-2-3-4 Analytical data for the pitch collections used:

IC	1	1	1	2	1	3	I	4	Ι	
A	1	7		14	1	5		7		
В	1	9	1	8	I	8		7	1	
Total	1	16		22		13		14	1	

Pitch Collection A:

Central Pitch: C5



Pitch Collection B: Central Pitch: B3



Verse II

Generative interval order: 2-3-1-4 Analytical data for the pitch collections used:

IC	I	2	Ι	3	1	1	I	4	
A	1	13		7	1	11		5	1
В		11	l	5	I	10		7	I
Total	1	24	 [12	1	21	1	12	

Pitch Collection A:

Central Pitch: C3



Pitch Collection B: Central Pitch: C4



Verse III

Generative interval order: 3-1-2-4 Analytical data for the pitch collections used:

IC	1	3	1	1	I	2	1	4	1	
Α	Ι	12		9	1	4	1	6	1	
В	Ι	13		4		9	I	3	1	
Total	ļ	25		13		13		9		

Pitch Collection A:

Central Pitch: F2



Pitch Collection B: Central Pitch: E4



Verse IV

Generative interval order: 2-1-4-3 Analytical data for the pitch collections used:

IC	1	2	1	1	Ι	4	Ι	3	1
A	1	11	1	6	1	6	1	8	
В	1	14		9		5		7]
Total		25	1	15	1	11	1	15	

Pitch Collection A:

Central Pitch: D4



Pitch Collection B: Central Pitch: A2



Verse V

Generative interval order: 3-1-2-4 Analytical data for the pitch collections used:

IC	Ι	3	Ι	1	i	2	I	4	I	
A		8	I	8		7	I	8	I	
В		12	1	7	I	9		5	I	
Total		20		15		16	!	13		

Pitch Collection A:

Central Pitch: C#3



Pitch Collection B: Central Pitch: G#4



Verse VI

Generative interval order: 1-3-2-4 Analytical data for the pitch collections used:

IC	l	1	1	3	I	2	1	4	1	
A	1	11	1	9		8		6	1	
В	I	16	1	8	1	15		2	1	
Total		27		17	!	23		8		

Pitch Collection A:

Central Pitch: F#3



Pitch Collection B: Central Pitch: G#4



Verse VII

Generative interval order: 2-1-3-4 Analytical data for the pitch collections used:

IC	ł	2	I	1	t	3	1	4	ł	
A	1	11	1	9	1	5	1	8		
В		11	1	12	1	6	1	6	1	
Total		22		21		11		14		=============================

Pitch Collection A:

Central Pitch: G5



Pitch Collection B: Central Pitch: C3



Verse VIII

Generative interval order: 1-3-2-4 Analytical data for the pitch collections used:

IC	I	1	I	3	I	2	1	4	l
A		7	1	11		1	1	9	
В	1	9	i	12	1	3	!	6	1
Total		16	1	23		4		15	

Pitch Collection A:

Central Pitch: D4



Pitch Collection B: Central Pitch: E4



Verse IX

Generative interval order: 3-1-2-4 Analytical data for the pitch collections used:

IC	I	3	1	1	I	2	Ι	4	1	
A		13	1	6		6	1	5	1	
В	1	11		13		3		6	1	
Total		24		19		9		11	1	

Pitch Collection A:

Central Pitch: A3



Pitch Collection B: Central Pitch: A3



Verse X

Generative interval order: 2-1-4-3 Analytical data for the pitch collections used:

IC	1	2	I	1	I	4	1	3	I	
A		10	1	5	l	8		7	1	
B		11		6	1	10	 I	3		
Total	1	21	1	11	1	18		10	1	

Pitch Collection A:

Central Pitch: F5



Pitch Collection B: Central Pitch: B4



Verse XI

Generative interval order: 4-1-2-3 Analytical data for the pitch collections used:

IC	Ι	4	I	1	1	2	ł	3	1	
A	1	11		8		0	l	8		 •
В	1	11	1	5	1	11		2	1	 •
Total		22		13		11		10		 •

Pitch Collection A:

Central Pitch: B4



Pitch Collection B: Central Pitch: D4



Epilogue (Amen)

Generative interval order:4-3-1-2Analytical data for the pitch collections used:

IC	1	4	I	3	1	1	1	2	1
A		10	I	6	1	7		5	l
В		9	1	6	1	6		8	;
Total	1	19	1	12		13	1	13	1

Pitch Collection A:

Central Pitch: G3



Pitch Collection B: Central Pitch: G3



i de la

Appendix IV: Data for the computer-generated sounds

attack order:

partial number of CF: channel A

⁻ channel B

Prologue								
central frequency (CF):								
channel A - 932.33]	Hz (Bbf	5)	chann	el B - 9	32.33 H	Iz (Bb5)	
number of partials:						•	-	
channel A - 23			channel B - 23					
sub-section articulation:	а	b	с	d	e	f		
attack order:	A/B	B/A	B/A	A/B	B/A	A/B		
partial number of CF:								
channel A	1	23	21	12	11	7		
channel B	1	23	19	16	4	12		
•••••••	-							
Verse I								
central frequency (CF):								
channel A = 573 25	H		chang	el R - 2	A6 04 F	I7 (B3)		
number of particles		,	Cham		,40.74 1	12 (DJ)		
number of partials.			.		-			
channel A - 23			chanr		./	c	_	
sub-section articulation:	a	D	C	a	e	I	g	
attack order:	B/A	A/B	A/B	B/A	B/A	A/B	B/A	
partial number of CF:								
channel A	10	8	4	12	11	14	8	
channel B	8	10	5	13	1	17	1	
Norma II								
verse II								
central frequency (CF):								
channel A - 130.81	Hz (C3))	chant	iel B - 2	261.63 I	tz (C4)		
number of partials:								
channel A - 8			chanı	nel B - 2	20			
sub-section articulation:	а	b	с	d	e	f		

 B/A A/B B/A B/A B/A A/B

Interlude I					
central frequency (CF):					
channel A - 87.31 I	Hz (F2)		channe	el B - 3	29.63 Hz (E4)
number of partials:					
channel A - 7			channe	el B - 2	3
sub-section articulation:	а	b			
attack order:	B/A	B/A			
partial number of CF:					
channel A	7	4			
channel B	1	23			
Verse III					
central frequency (CE):					
channel A = 87 31 1	H7 (F2)		chann	el B - 3	29 63 Hz (F4)
number of partials:	(1 <i>L</i>)		Çnann	010 0	27.05 XXX (D+)
channel A - 7			chann	el B - 2	2
sub-section articulation:	n	h	cilaisii	d	ю Л
attack order:	4 A/R	B/A	۲ ۸/R	A/R	R/A
nortial number of CE.	ΜD	DIA	~~~	лур	DIA
channel A	2	2	3	6	1
channel R	21	12	11	14	1
channel B	21	12	11	14	4
Verse IV					
central frequency (CF):					
channel A - 293.66	Hz (D4))	chann	iel B - 1	10.00 Hz (A2)
number of partials:					
channel A - 10			chann	el B -	9
sub-section articulation:	а	b	с	d	
attack order:	A/B	B/A	A/B	A/B	
partial number of CF:					
channel A	10	9	2	2	
channel B	5	1	8	9	
Verse V					
central frequency (CF):					
channel A - 138.59	H7 (C#	3)	chanr	el B - 4	415.30 Hz (G#4)
number of partials:		.,	onum		
channel A . O			chang	nel B _ f	73
sub-section articulation:	2	h	chain	с. 19-2 А	
sub-section articulation.	а <u>к</u> ло	0 8/10	R/A	R/A	
anack order:	A/D	ND	DIA	DIA	
partial number of CP:	7	2	5	=	
channel A	7	2 A	5 1	20	
channel B	1	4	Y	4 0	

65

s

•

Verse VI				
central frequency (CF):				
channel A - 185.00 I	Hz (F#3)	chann	el B - 415.30 Hz (G#4)
number of partials:	•			
channel A - 13			chann	el B - 23
sub-section articulation:	а	Ь	с	
attack order:	и 12/л	B/A	ÅЛВ	
and of CE	D/A	DIA	лIJ	
partial number of CF:		0		
channel A	0	δ	4	
channel B	19	5	19	
Verse VII				
central frequency (CF):				
channel A - 783.99 I	Hz (G5)		chann	el B - 130.81 Hz (C3)
number of partials:				
channel A - 23			chann	el B - 9
sub-section articulation:	อ	Ь	с	d
attack order:	R/A	B/A	Δ/R	Ř/A
partial number of CE.	DITL	DITA		
partial number of Cr.	2	1	2	22
	3	Ţ	2	22
channel B	2	T	2	7
Verse VIII				
Verse VIII central frequency (CF):				
Verse VIII central frequency (CF): channel A - 293.66	Hz (D4)		chanr	nel B - 329.63 Hz (E4)
Verse VIII central frequency (CF): channel A - 293.66 I number of partials:	Hz (D4)		chanr	el B - 329.63 Hz (E4)
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22	Hz (D4)		chanr	nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation:	Hz (D4)	b	chanr	nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order:	Hz (D4)	b A/B	chanr chanr	nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CE:	Hz (D4) A/B	b A/B	chanr chanr	uel B - 329.63 Hz (E4) uel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF:	Hz (D4) , A/B	b A/B	chanr chanr	nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel A	Hz (D4)	b A/B 3	chanr chanr	nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B	Hz (D4) A/B 8 2	b A/B 3 12	chanr chanr	uel B - 329.63 Hz (E4) uel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B	Hz (D4) Å/B 8 2	b A/B 3 12	chanr chanr	nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II	Hz (D4) Å/B 8 2	b A/B 3 12	chanr chanr	nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II central frequency (CF):	Hz (D4) A/B 8 2	b A/B 3 12	chanr chanr	nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II central frequency (CF): channel A - 293.66 I	Hz (D4) A/B 8 2 Hz (D4)	b A/B 3 12	chanr	nel B - 329.63 Hz (E4) nel B - 23 nel B - 329.63 Hz (E4)
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II central frequency (CF): channel A - 293.66 I number of partials:	Hz (D4) Å/B 8 2 Hz (D4)	b A/B 3 12	chanr chanr chanr	nel B - 329.63 Hz (E4) nel B - 23 nel B - 329.63 Hz (E4)
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II central frequency (CF): channel A - 293.66 I number of partials: channel A - 22	Hz (D4) A/B 8 2 Hz (D4)	b A/B 3 12	chanr chanr chanr chanr	nel B - 329.63 Hz (E4) nel B - 23 nel B - 329.63 Hz (E4) nel B - 329.63 Hz (E4)
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation:	Hz (D4) A/B 8 2 Hz (D4) a	b A/B 3 12	chanr chanr chanr chanr	nel B - 329.63 Hz (E4) nel B - 23 nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.661 number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II central frequency (CF): channel A - 293.661 number of partials: channel A - 22 sub-section articulation: attack order:	Hz (D4) A/B 8 2 Hz (D4) a B/A	b A/B 3 12	chanr chanr chanr chanr	nel B - 329.63 Hz (E4) nel B - 23 nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.661 number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II central frequency (CF): channel A - 293.661 number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF:	Hz (D4) A/B 8 2 Hz (D4) a B/A	b A/B 3 12	chanr chanr chanr chanr	nel B - 329.63 Hz (E4) nel B - 23 nel B - 329.63 Hz (E4) nel B - 329.63 Hz (E4)
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A - 22	Hz (D4) A/B 8 2 Hz (D4) a B/A 12	b A/B 3 12	chanr chanr chanr chanr	nel B - 329.63 Hz (E4) nel B - 23 nel B - 329.63 Hz (E4) nel B - 23
Verse VIII central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A channel B Interlude II central frequency (CF): channel A - 293.66 I number of partials: channel A - 22 sub-section articulation: attack order: partial number of CF: channel A - 22	Hz (D4) A/B 8 2 Hz (D4) a B/A 12	b A/B 3 12	chanr chanr chanr chanr	nel B - 329.63 Hz (E4) nel B - 23 nel B - 329.63 Hz (E4) nel B - 23

Verse IX			
central frequency (CF):			
channel A - 220.00	Hz (A3)		channel B - 220.00 Hz (A3)
number of partials:			
channel A - 17			channel B - 15
sub-section articulation:	а	b	с
attack order:	A/B	A/B	B/A
partial number of CF:			
channel A	9	9	9
channel B	9	6	7
Verse X			
central frequency (CF):			
channel A - 698.46	Hz (F5)		channel B - 493.88 Hz (B4)
number of partials:	. ,		
channel A - 23			channel B - 23
sub-section articulation:	а	b	
attack order:	A/B	A/B	
partial number of CF:			
channel A	9	11	
channel B	2	10	
Interlude III			
central frequency (CF):			
channel A - 493.88	Hz (B4))	channel B - 293.66 Hz (D4)
number of partials:			
channel A - 23			channel B - 22
sub-section articulation:	а		
attack order:	A/B		
partial number of CF:			
channel A	11		
channel B	11		
Verse XI			
central frequency (CF):			
channel A - 493.88	Hz (B4))	channel B - 293.66 Hz (D4)
number of partials:			
channel A - 23			channel B - 22
sub-section articulation:	а	b	
attack order:	B/A	A/B	
partial number of CF:			
channel A	7	11	
channel B	6	7	

67

D
Epilogue (Amen)	
central frequency (CF):	
channel A - 196.00	Hz (G3)
number of partials:	
channel A - 15	
sub-section articulation:	а
attack order:	B/A
partial number of CF:	
channel A	3
channel B	1

channel B - 196.00 Hz (G3)

channel B - 14

•••

•