

# Theories of Evolutionary Algorithms and a 'New Simplicity' Opera: Making *Sappho's Breath*

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## Abstract

The making of the author's computer music chamber opera, *Sappho's Breath*, is described including the use of a genetic/evolutionary algorithm, the aesthetic background and the practical limitations for both the piece and the use of the algorithm. The opera is scored for soprano, hand-held percussion, and electronic computer music on recorded medium. This one-act opera is comprised of an overture and twelve scenes, six of which are arias. The program used to help create the work, called *GenDash* (Waschka 1999) was designed and coded by the author. Beth Griffith, who gave the first performance in April of 2001, commissioned the work. Regarding theoretical issues, this research suggests that musical questions related to artificial life models can be unique and further argues that models both similar and at variance to those at work in the natural world can be useful in composing new music.

## Introduction

In recent years some composers and/or engineers have attempted to make use of artificial life models of different types to create various kinds of music or musical sounds. The range of these musical projects extends from harmonizing chorale melodies in the style of J.S. Bach (Horner & Ayers 1995; Maddox & Otten 2000) to timbre development (Horner et al 1992; Horner & Goldberg 1993; Horner et al 1993; Fujinaga & Vantomme 1994; Horner et al 1995), to attempts to find efficient synthesis techniques that produce sounds that mimic acoustic instruments (Horner et al 1992; Vuori & Valimaki 1993; Horner et al 1996) to the creation of a musically intelligent soloist for jazz standards (Biles 1994; Biles & Eign 1995; Biles 1998) to attempts to utilize these artificial life models for the making of new music (Waschka 1999; Thywissen 1996; Miranda 2001).

This article will describe the application of a particular genetic algorithm program: *GenDash* (Waschka 1999), to a particular compositional problem: composing arias consisting of single line vocal music, and a specific piece: *Sappho's Breath*, a one-act opera for soprano, hand-held percussion, and electronic computer music on recorded medium. In describing *Sappho's Breath*, and the utilization of evolutionary algorithms in the making of that work, this article will indirectly suggest possible answers to two important questions:

- 1) Are there questions and answers about the use of artificial life models in the making of new music that are unique and therefore require unique treatments?

And

- 2) What functional theories of evolutionary development are useful in creating new music?

The answers to these questions as suggested by this particular composition will almost certainly prove to be only individual possibilities among many other viable answers. Nevertheless, the value of the approach outlined here is clear: the piece was completed and successfully performed.

### **Background and Previous Work**

The author has for many years created pieces for traditional ensembles or for electronics and traditional instruments using various kinds of compositional algorithms of his own design (Waschka 1983; Waschka 1985; Waschka & Ferreira 1988; Waschka & Kurepa 1989; Waschka 1990; Waschka 1992, Burns 1994; Kurepa & Waschka 2000). A number of these pieces utilized evolutionary algorithms. These works include pieces for speaking vocal soloist, chamber orchestra, instrument and tape, string quartet, and an opera with electronic computer music parts. Among the most important of these works are *Empty Frames* (Waschka 1996) for chamber orchestra, duration ten minutes, first performed by the Raleigh Civic Chamber Orchestra, and *Saint Ambrose* (1998-2000) (Waschka 2000) a one-act opera consisting of an overture and 11 scenes. Scored for saxophonist/actor, computer music on recorded medium, and visual projections, and with a duration forty minutes, *Saint Ambrose* was commissioned by Steve Duke. Preview performances have taken place in Chicago, in Dayton, Ohio, (the North American Saxophone Alliance festival) at Northern Illinois University, and at North Carolina State University. The premiere performance of *The Definitions Aria*, a large-scale, made-to-stand-alone aria from *Saint Ambrose* was given by Duke at the World Saxophone Congress in Montreal in 2000 and that aria has since been taken up by other saxophonists and toured in various parts of the United States. In addition, there is a large-scale string quartet, *String Quartet: Laredo*, duration twenty minutes, from 1999 that has yet to be performed.

Each of these works was created using a subsequent version of the *GenDash* program that has grown or been altered with the making of each successive piece.

### ***Sappho's Breath***

The composition described here is *Sappho's Breath*, a one-woman chamber opera scored for soprano, electronic computer music in a recorded medium, and hand-held percussion. Commissioned by soprano Beth Griffith, the piece is approximately thirty minutes in duration. Ms. Griffith gave the first preview performance of the work on 17 April 2001. The opera requires only minor theatrical props: a candle and candle holder consistent with ancient Greece, a simple dress to serve as a costume, one lighting set and two lighting cues -- fade up and fade down. The opera is in one act consisting of an overture and twelve scenes. Six of the scenes consist of an aria only. A complete listing of the overture and scene titles is given below:

Overture: Up From Hades; Scene 1: I Am Come; Scene 2: Aria: Tell Everyone; Scene 3: Yes, Perhaps; Scene 4: Aria: Afraid Of Losing You; Scene 5: Ultimately; Scene 6: Aria: Thank You; Scene 7: Before I Tell; Scene 8: Aria: Tonight; Scene 9: Yes, I Loved; Scene 10: Aria: I Hear; Scene 11: Pitiful Modern Mortals; Scene 12: Aria: I Have No Complaint

The opera is based on the poetry of Sappho, one of the most famous of Greek writers. The translation of her works into English used in the opera (by the kind permission of the University of California Press) is that of Mary Barnard (1958).

Sappho flourished on the island of Lesbos around 630 BCE. Almost all of Sappho's poetry has come down to us in fragmentary form. Preserved on papyrus scrolls, many of these scrolls were torn into strips and pasted together to form cartonnage coffins while other strips have been dug up in ancient rubbish heaps in Egypt and some were found stuffed into mummified crocodiles. Other writers in manuscripts that have survived preserved some poems or parts of poems. We know very little about her life and much of what is claimed about her is disputed. *Sappho's Breath* considers our continuing fascination with her work.

Those interested in Sappho can look to a shelf of books including various translations and studies such as those by Jim Powell (1993), André Bonnard (1996), and studies by, or edited by Holt Parker (1993), Ellen Greene (1996), M. Reynolds (2000), and P. duBois (1996). (These are merely representative references. Each work will direct those seeking more information to many other writings.) The Barnard translation shows what Dudley Fitts called the "pungent downright plain style" of Sappho's work. In composing the work the author sought to make a simple, spare, and elegant setting that corresponds to the directness of the poetry and to an understanding of the Greek art of the period. The title comes from the fragment "only breath, words which I command are immortal."

The structure of the opera alternates acted, spoken text with arias. The texts of the arias are spoken by the singer during each aria. The vocal music is sung on vowel sounds of the singer's choice. While singing, she also plays small percussion instruments including five-inch cymbals, a tambourine, castanets, and a triangle. The spoken/acted parts, scenes 1, 3, 5, 7, 9, 11 have recorded electronic computer music parts. The arias do not. The arias are solely for the soprano singing and playing the percussion instruments. The overture consists of recorded electronic computer music. During the overture the soprano (as Sappho) makes her appearance on stage and in the audience, but does not speak.

### **Application of the Algorithm**

In this case the author, as composer, did have some help in the form of a single self-imposed limitation: to attempt to make the work as simple, direct, and elegant as possible. The goal was to musically match the Sappho translations – to create a «New Simplicity» opera, a radical contrast with more complex works. Of course, what terms like «elegant» and «direct» mean varies tremendously from person to person. In this case, however, it resulted in the composer deciding that no text would be sung and that all of the arias would be single line melodies with easy percussion parts and without electronic accompaniment. No other limitations existed at the outset of the compositional process.

With these things in mind, an evolutionary algorithm program called *GenDash* implemented in Forth and running on a Macintosh was utilized. In this usage it has the following attributes:

1) the fitness function is a random selection; 2) various crossover points are used; 3) space is set aside for individuals that are unheard in the current generation but may reappear and/or

breed in a later generation; 4) space is set aside for an intact individual which may breed in a succeeding generation; 5) a two parent model is used; 6) all individuals that are «born» in any generation are heard.

The initial population represents twenty-six measures of music. In making *Sappho's Breath*, typically about five generations were needed for each aria. When a new generation is called for, the program randomly selects which individuals will breed, how many times, and with which other individuals. The program randomly selects some information that is retained in a «recessive traits» area and may be accessed in the next generation. It also randomly selects an individual that is retained intact and may breed in the next or succeeding generation. Since the fitness function is a random selection, the choice of which individuals will breed does not require that a large number of individuals be compared with a complex fitness function. As a result, the computing of all generations needed for a particular aria was always completed in approximately two seconds. In this way, any potential problems with a «fitness function bottleneck» are immediately resolved. Even in other works by the author such as *Empty Frames* and *Saint Ambrose*, where the number of generations computed for each section of music was much greater, there was never a problem with computing speed or efficiency using this method.

As mentioned previously, various crossover points were used. For example, in a measure with four beats, crossover points could occur after the first beat, after the second beat, or after the third beat. In a three-beat measure there were two choices: after the first beat and after the second beat. Therefore, in the case of the three-beat measure whichever crossover point is selected will mean that only one beat will be taken from one of the «parent» individuals. Similarly, two of the three possibilities in the case of the 4-beat measure produce a situation in which only one beat of musical material will be taken from one of the «parents». The use of these various crossover points meant that sometimes the contributions of individual parents were atomized to the point that an appropriate amount of the material resembled the basic building blocks of traditional melodic material. Consequently, while there remains a desired parents/offspring likeness, the resultant melodies are not heard as random rearrangements of the initial populations.

This artificial life model implicitly suggests that while in the natural world powerful, efficient, and recognizable evolutionary forces can be at work over long periods of time, in this particular model chance plays an important role. Furthermore, such a model acknowledges that when working in the genre of avant-garde art music that the composer will not often immediately recognize which individuals are «good». The composer can restart the procedure, probably with a new initial population, if, after a number of generations, it becomes clear that the results are poor. In this way the composer can serve a fitness function role, but only at a «global» level. This type of artificial life model de-emphasizes the area of the fitness function and emphasizes the importance of the initial population. In the case of *Sappho's Breath* some of the initial populations were drawn from Greek and Medieval songs. The composer intuitively created other initial populations.

The melodies that resulted were useful and successful. They function well within the context of the opera and some or all will function equally well as a group of arias sung outside the opera as voice recital material. The opera was very well received in its special preview performance.

### **Answering the Questions**

The methods employed in the making of *Sappho's Breath* suggest that there are questions and answers about the use of artificial life models in the making of new music that are unique and therefore require unique treatments. These attributes can be generalized to much new music in three important areas: first, in terms of acoustics, second, in terms of aesthetics, and third, in terms of cost.

Regarding acoustics, except for the limitations imposed by the range and sensitivity of human hearing, there are no physical constraints placed on the composer. An architect's building must adhere to certain engineering principles so that it will remain standing and not be dangerous to people in or around the structure. Even more abstract forms of art than architecture face some limitations. In the documentary film, *The Collaborators*, about the collaborative work of John Cage, Merce Cunningham, and Robert Rauschenberg, during an interview segment both Cunningham and Rauschenberg complain that because Cage's work was the least corporeal, he always had the most freedom. Rauschenberg, comments on the limitations of size, weight, material, et cetera that constantly constrained the visual art of his set and costume design. Cunningham notes that he was not free in his use of chance techniques in choreography because such techniques could lead to dancers running into each other, «but if John's sounds ran into each other, no one got hurt.»

Regarding aesthetics, the obvious question is what makes for good new music? What is meant by «new» here is both «currently made», and «experimental, different, non-formulaic, avant garde.» Most composers would claim that upon hearing a piece they are confident of their ability to judge its quality and perhaps to even point out what about the piece was particularly good. However, that is very different from knowing, a priori, what will make a good, non-formulaic, experimental, or avant garde piece. Many composers do not have this a priori knowledge, and, if they did, could easily find they were no longer interested in composing. To paraphrase Morton Feldman: When we get to the point where we don't know what we're doing, that's when we have truly started to compose. This is not true for all composers -- those who wish to write in a clearly eighteenth-century, tonal, European style may in fact have very detailed ideas about the rules for making a piece, as might an integral serialist. For those who don't have a very specific idea of the end result in mind as they begin composing, developing evolutionary priorities as defined by a fitness function could easily prove impossible.

Regarding cost, there are clear expense differences between building a bridge or a car and making and presenting a piece of electronic computer music. Even computer music for traditional performers is much less costly than many other kinds of projects (artistic or otherwise) to which artificial life models might be applied. Once a certain relatively low expense standard is reached, a composer can present a piece that will last at least as long as the typical audience is willing to sit still to hear it. In the case of electronic music the composer can easily make pieces that last much longer than that for only tiny increases in cost.

These factors create a situation in music that is fundamentally different from the possible use of evolutionary models in many other fields. In numerous other fields a problem is well defined by safety considerations (the building must stand), functionality (the car must move efficiently), and cost (bridge cannot cost more than X monetary units). In these non-musical situations, at least certain aspects of what will constitute and satisfy the criteria of a good solution are completely, or at least partially, known. When compared with most other art forms, music maintains one of the most, if not *the* most, flexible position.

Consequently, in light of these arguments and the examples of *Saint Ambrose* and *Sappho's Breath*, it seems a reasonable conclusion that the use of EA's/GA's/artificial life models in the making of new music requires unique treatments.

To the question: What functional theories of evolutionary development are useful in creating new music? *Sappho's Breath* suggests an interesting possibility. One way of looking at the model at work in *Sappho's Breath* is not as an evolution toward a superior individual solution to a well-constrained problem, but as a description of evolutionary failure (that succeeds musically).

The initial populations involved in the making of *Sappho's Breath* are small. The number of generations created is also small; nevertheless there is a clear diminution of diversity in that population and a tendency towards replication of one or a few individuals. If the stage of simply replicating one or a few individuals were to be reached, the music would soon become devoid of interest. (In the natural world, such a group might be headed for trouble or extinction: the problems of incest or the disaster of a narrowly evolved species unable to cope with a change in the environment.) In music, however, short of simple and potentially endless repetition, this narrowing of the diversity of the material can provide a sense of form. As the piece proceeds, the repetition of certain elements or whole individuals allows the listener to make connections with other parts of the work. Finally, the increased similarity of the musical material and the repetitions of motives or measures can provide for both the composer and the audience a sense of closure, and help to bring the piece or section to a «natural» and «satisfying» end. If the composer finds that the succeeding generations converge too quickly to be successful in the piece she or he is working on, there are a number of simple solutions. (A situation in which this might arise would be the case of composer with a commission for a 15-minute work, but a convergence that prompts an end to the piece occurs at circa 10 minutes into the piece). The potentially easiest solution is to re-initialize the population and run the generations again. The time required to do this is literally seconds. Another easy method is to increase the size of the initial population. It should be noted that the author has experienced a convergence that clearly determined that the piece must end on one occasion: the making of the chamber orchestra piece *Empty Frames* which used as its initial population material from the second movement of Beethoven's *Symphony 7*. That work has a duration of ten minutes. Depending on the desired final length of the piece, the style of music, and the predilections of the composer, the size of the initial population could be adjusted before any runs of the program created the needed generations. A certain amount of experience working with a program of this type would probably enable most composers to estimate beforehand the needed size of the initial population. While there is a movement towards convergence in the arias of *Sappho's Breath* no additional runs of the program were needed because of premature convergence.

## Conclusions

The example of *Sappho's Breath* suggests that music's non-corporeal, non-functional nature, together with the experimental nature of new art, mandate the use of special kinds of artificial life models and techniques in the making of new compositions. Furthermore, potential artificial life models for use in music should not be limited to models that continue indefinitely. Finally, as evidenced by *Sappho's Breath* and other pieces, including *Saint Ambrose*, musical mappings in which the process is the focus -- not a hunt for a single best solution -- can be easier to implement, efficient, and musically successful.

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