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The Assembling of *Stria* by John Chowning: A Philological Investigation

This article starts from the assumption that musicology needs methods borrowed from philology for studying computer music. The analysis of the creative and revision process that John Chowning carried out in the realization of *Stria* (1977) is made possible by textual criticism and interpretation based on digital and audio sources, sketches, and oral communications.

This research moves from the hypothesis that *Stria* exists in several versions and follows the historical genesis of the assembling of the sections. Conclusions trace the various stages of the assembling process, from the very first synthesis of the piece to two different and coexisting four-channel and stereophonic versions.

Theoretical Introduction

The electroacoustic music work is an "apparently unclassifiable object," fragmented between several human and technological agents, different moments of creation, realization, and performance, and various theoretical concepts (Barrière 1990). Any musicological study must start from the heterogeneous documentation of the compositional process, which includes compositional sketches and various types of scores—if one considers the concept of "text" as a physical object where the sign represents the sound.

Philology of music states, in fact, that "text" is a "reference model"—the place where projects are written in a tentatively stable form to preserve and transmit it (Caraci Vela 2005). Nevertheless, the text within electroacoustic music is not necessarily a visible trace. As Angela Ida De Benedictis writes about analog music, text is also the support—the tape—that preserves the sound (De Benedictis 2004). In computer music, it is also the data-storage device and digital data with which a machine generates a computation that is not an immediately intelligible symbol. Moreover, electroacoustic music often implies the role of the musical assistant, or the performance assistant, or someone who translates compositional ideas into digital data: These all are human agents who carry on a codification through the processes of writing. The study of the process of composition (the term *écriture* would be more appropriate) and the text must be applied to the tape, the CD, digital memory, the digital score, and so on, because "these texts do not certainly show a visible context of writing, but do certainly maintain its essence and its reproduction technology" (De Benedictis 2004, p. 247).

As the last resort, among these different texts converging to the electroacoustic work, and within this actual culture where aurality-orality and *écriture* are blurred, the composer's "mental" text is fundamental. It represents the musical intention, and it is worth being analyzed if one considers it as a support for the writing of the musical thought. Obsolescence and preservation are crucial problems in the study of electroacoustic music. Therefore, mental texts (of composers, technicians, etc.) are important to the preservation and analysis of musical works.

Analysis of the sources is therefore the primary method to study electroacoustic music: It is a question of examining the texts as a process of writing, conceived to reach the electroacoustic "arborescent reality" (as defined by Barrière 1990). This is the refrain of my investigation on *Stria* by John Chowning, "a music which did not resemble any other music, touching for the beauty of its relaxation and sound concatenation" (Risset 2005, p. 50). Together with the presence of objective witnesses, the analysis benefits from and is forced to take into account the presence of the author, who can help elucidate and sometimes complicate the analysis with his memories. These types of sources of course need to be interpreted, verified, and compared with physical sources, but are fundamental to allowing the analysis to proceed. Without the presence of John

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Chowning, his comments, recollections, feedback, and supervision, this research could often have encountered a "dead end." This approach occasionally obliges the musicologist to "mix" philological and historical analyses to reconstruct the compositional process. Even if that could seem a confusion of plans and a renunciation of adopting an objective consideration of the sources (particularly audio sources), on the other hand it is necessary. However, this is why I do not go into details—it goes beyond my competence—concerning physical aspects of support material (acetate or other), condition (state of degradation of the tape, etc.), state of preservation, number of segments of the tape, and so on. I consider only elements and aspects useful for my purposes, which are the development of the assembling process of the musical piece.

Stria: A Short Overview

In 2005, the GRM (the French Institut National de l'Audiovisuel) published the volume *John Chowning: Portraits polychromes* (Castanet et al. 2005). The book presents a collection of interviews with the composer, as well as articles on his musical works and the impact of his research. Moreover, it contains some musicological analysis of two of the four pieces (*Turenas* and *Stria*) that Mr. Chowning composed between 1971 (*Sabelithe*) and 1981 (*Phoné*).

Bruno Bossis's essay in this volume draws on a previous article by Matteo Meneghini and reconstructs various aspects of the realization of the piece in terms of macrostructure, frequency system, Golden Mean, and so forth (Meneghini 2003; Bossis 2005). Nevertheless, because the philologist pays attention to different sources, some aspects related to the text of *Stria* emerged that make the piece worth being further analyzed. After Meneghini's article and Borghesan's attempt to re-synthesize the piece following Borghesan (2005), I discovered some additional aspects of the piece, and new details and discrepancies emerge in the versions. As a matter of fact, analysis reveals at least three versions of *Stria*, which shows this is a very interesting case from a philological point of view.

Stria is the result of the musical application of Mr. Chowning's research into frequency modulation (FM). October 2007 marks the 30th anniversary of the completion of *Stria*, and it also marks the 40th anniversary "since I stumbled on the FM synthesis algorithm!" (Chowning 2006). Mr. Chowning recently reminisced about the precise circumstances and historical dates during a seminar and concert he gave in Buenos Aires together with Jean-Claude Risset and Max Mathews. On that occasion, Mr. Risset showed to the audience some notes dated 18 December 1967 that he made when Mr. Chowning visited Bell Laboratories and described the FM data from some personal undated notes. Mr. Risset's notes are useful to establishing Mr. Chowning's sketches and their discovery: the origin of the FM applied to sound synthesis dates Fall 1967. (As an historical detail, Mr. Chowning adds that he had visited Bell Labs also in Summer 1967, but he has no recollection of mentioning FM to Jean-Claude Risset and Max Mathews, which he surely would have done had the discovery already been made.) Mr. Risset later used FM synthesis in part of his piece *Mutations*, which was completed in 1969 and involved Mr. Chowning's work with the moving sound-sources project. *Mutations*, then, is the first composition in which FM was used (Chowning 2006).

In 1974, after a sabbatical year during which he wrote his famous article on FM synthesis (Chowning 1973), and after being informed by Stanford University that his position was not renewed (Means 2005; Castanet et al. 2005), Chowning came to Berlin with a DAAD fellowship for a research stay of one year (as composer in residence) at the German Arts Academy. Mr. Chowning obtained this position through the recommendation of György Ligeti, who was aware of his situation at Stanford. At the Technical University, he could use only a PDP-10 computer with no sound converter, so he decided to study deterministic processes (Roads 1985). He worked deeply on the FM technique applied to composition, especially discovering that a carrier-to-modulator frequency ratio composed of powers of the Golden Section yielded low-order side-band components that are also powers of the Golden Section.

Mr. Chowning thought about the composition

with such intensity that when he finally decided to realize his musical project, he completed the work in only four months at the Stanford Artificial Intelligence Laboratories, where he had returned. This occurred during the summer of 1977, from July to October, thanks to an IRCAM commission. In fact, this was one of IRCAM's first composition commissions, as the musical production in Paris had started the year before (Zattra 2003). It was also one of the very first computer-music pieces for solo tape composed at IRCAM. (Also that year, Jean-Claude Risset realized *Inharmonique*, for voice and synthesized sounds (Lorrain 1980).)

Stria was presented on 13 October 1977 at 8:30 PM, at the Centre Pompidou (Grande Salle Polyvalente). The concert series also included Luciano Berio's *Sequenza* for voice and electronic, together with premieres by H. Pousseur, M. Decoust, and J. Druckman. The concert was part of a presentation by Berio entitled "La Voix des voies," and within the Exposition électroacoustique by Luciano Berio (14 events conceived as "spectacle audiovisuel" with commissions from Decoust, Denisov, Druckman, Eloy, Pousseur, and Stockhausen) (Rivière and Pouillon 1976). The *Passage du XXe siècle* catalogue indicates another concert on 1 October (concert "Exposition électroacoustique"), with music by Mr. Chowning, Mr. Stockhausen, Mr. Druckman, and Mr. Pousseur (Rivière and Pouillon 1976). Nevertheless, Mr. Chowning notes that he arrived in Paris only a day or two before the 13th and stayed with Jean-Claude Risset and his family (Chowning 2005c).

Stria corresponds to an intermediate point between parameter-by-parameter composition and automatic composition. Mr. Chowning declares that during the composition of the piece, he seemed to always want more and more control over detail and ended up for this reason with a large number of variables. Because he had spent many hours thinking carefully about controlling a larger-scale formal structure, he then wrote an algorithmic procedure called `event2` that brought an even greater reward in compositional inspiration and control. Mr. Chowning believes that computers are fundamentally capable of providing more than is requested or envisioned, so that one feels, as a composer, enormously empowered—"not surprising, when one considers that a given hardware and software represents tens of thousands of human-years of thought about thought and invention" (Chowning 2004).

Automatism and the extreme control of each musical parameter related to the Golden Mean could lead one to think of a serial approach to Chowning's music. He concedes that this system is interesting, but all the radicalism of that avant-garde approach did not completely satisfy him. He rather looks at the organization techniques of the musical material of 1,000 years of Western music history: spatial organization of pitches, counterpoint, and control of the harmonic and inharmonic spectra. Nevertheless, all those dimensions must always be related to perception, which remains the central moment of the musical verification (Gayou 2005).

The Golden Mean is the reference ratio that controls the spectral (vertical) space (Meneghini 2003; Bossis 2005), and the related Fibonacci sequence inspires the overall timing of the piece (horizontal space); the two are closely related. *Stria* is "a completely abstract construction" and non-referential. The composer writes that it is "something that could be done by a computer but could not be done by any other electronic device. With any sort of analog synthesizer, I don't think it's possible just because they don't have the precision or the programming as part of their structure. It's a piece that is most uniquely tied to the digital domain" (Chowning 2005c).

General History of the Assembling Process

At the beginning of its compositional process, *Stria* was conceived as a piece that should have been realized in real time. It was originally planned for the Samson Box, a real-time digital synthesizer designed by Peter Samson of Systems Concepts Company. Peter Samson began his research in 1974 to develop a large-scale digital sound synthesizer controlled by a mainframe computer, capable of producing 256 independent sound sources in real time (Roads 1996, p. 918). The Samson Box was not finished in time, however (it was delivered to the Stanford Center for Computer Research in Music and Acoustics—

CCRMA—in late 1977). Thus, the piece was realized in sections, converted and recorded from the computer (a Digital Equipment Corporation PDP-10) onto four-channel analog tapes—one tape for each section—using a Scully four-channel half-inch tape recorder, in September and October 1977. Afterward, *Stria* was never realized on the Samson Box or any other real-time device. Today, a real-time rending would of course be possible. Computation was a problem when *Stria* was conceived, but now, "78 oscillators (26 *Stria* instruments using 3 oscillators per instrument) would be easily achieved on any laptop, and I hope that a real-time version will soon see the light" (Chowning 2005c).

The composer could not realize the work onto a single tape at Stanford because, on the one hand, the PDP-10 did not have enough digital memory to store more than a certain number of samples, and on the other hand because CCRMA had only one four-channel analog tape recorder. Mr. Chowning then took the tapes to IRCAM in Paris, where, as he remembers, there were many four-channel recorders: "It seemed to me then, they were used as door stops even!" (Chowning 2004). At IRCAM, he was able to mix the sections into the complete piece. No IRCAM technician was involved in the production, except for Andy Moorer, who had worked at Stanford and at the time worked at IRCAM. Mr. Moorer, who had given Chowning instruction in the SAIL (Stanford Artificial Intelligence Language) language four months earlier, simply helped in the starting and stopping of tape recorders to make the final tape (Chowning 2004, 2007).

Mr. Chowning remembers that he was not perfectly content with the timing of the mix of this first version (Chowning 2005c). Besides, immediately following the first performance, Luciano Berio and Cathy Berberian went from the audience to speak to him. They seemed to like the composition, but Berio suggested—and Mr. Chowning agreed—that it needed little adjustments, particularly in the duration, which could be shorter in some points without spoiling its beauty and proportions. The morning following the concert (14 October), Mr. Chowning reassembled the sections and truncated some other to what he now calls the "CCRMA version," which is the version that he returned with to Stanford.

According to the *Computer Music Journal* 1:3 (June 1977), the first performance of the CCRMA version was scheduled for 26–30 October 1977, where it was performed during the International Computer Music Conference at the University of California, San Diego (Chowning and Keislar 2007).

In 1984, a performance of *Stria* took place at IRCAM, but I did not find any article or recording documenting the event. The IRCAM Web site records two dates: 13 January and 21 June, both at the Espace Libre (IRCAM 2005). There are no firsthand accounts whether the version played was the first long version or the reduced version. However, Mr. Chowning believes that, as he remembers, there was no other version at that moment than the reduced version (Chowning 2006).

In 1988, the Wergo label initiated the Digital Music Digital series on the recommendation of Johannes Goebel. Wergo dedicated a CD to Mr. Chowning's works (Chowning 1988). This was one of the first series of digital discs in the world, conceived for the preservation of early computer music. The project had started in 1986 involving Johannes Goebel, Max Mathews, Patte Wood, CCRMA, and—from 1990—ZKM, and it was named IDEAMA. Its goal was to preserve the most important and endangered early electroacoustic works and make them publicly available. *Stria* was published together with *Turenas, Phoné,* and *Sabelithe.*

Through the course of my initial research, it had been evident that *Stria* was realized in different steps and has had different durations and descriptions since its first conception. This soon meant that I was facing an interesting musicological case of a computer piece with multiform identity that required philological investigation. The logical aim of this study was therefore to try to answer the following questions: In how many versions does *Stria* exist? Are those versions different and authorized redactions of the piece, or did they escape Mr. Chowning's control? Which is the final version?

Sources

The sources shown in Table 1 represent the significant evidence and extant documentation (in some

Table 1. Sources for the Study of *Stria*

Written sources	
TbM1	Description: Toby Mountain's graphical score of the piece, unpublished Reference: Mountain 1981 Duration: 15'46"
TbM2	Description: Toby Mountain's sketches for the analysis Reference: Mountain 1980
TM-LK	Description: short text by Tod Machover quoting an unpublished interview with the composer by Lev Koblyakov Reference: Machover 1984 Duration: No duration marked
DJ	Description: Dodge and Jerse's scheme; graph of the compositional structure Reference: Dodge and Jerse 1985, p. 126 Duration: 18'
RD	Description: Roberto Doati's analysis; musicological analysis of the compositional process, unpublished Reference: Doati 1988 Duration: two durations emerge: 15'46" (*4-ch*) and 16'57" (*Wergo*)
IR	Description: IRCAM Web site (written documentation of the piece) Reference: IRCAM 2005 brahms.ircam.fr/ Duration: 15'
Audio sources	
4-ch	Description: Roberto Doati's four-channel version; digitization made from an analog four-channel tape (Mr. Doati's personal archive) Reference: Doati 1988 Duration: 15'46"
WER	Description: Wergo CD Reference: Chowning 1988 Duration: 16'56"
IR-ta	Description: IRCAM's four-channel tape No dating on the box Duration: unknown
IRdig	Description: IRCAM's digitization from the four-channel tape (CD-ROM provided by John Chowning, dated 6 January 2005); sampling rate is 48 kHz Reference: Mr. Chowning's personal archive Duration: 17'26"

Table 1. (continued)

Computational sources	
JCdig	Description: handwritten notes, computer file printout, and unpublished manuscript with digital data for the calculation of the structure of the piece. Reference: Chowning 1977a–e, 1977(?)a, 1977(?)b, 1978a–b Duration: each section (from `TO.MEM` to `END.MEM`) shows a different duration

cases not published) dedicated to the piece considered for this research. Recall that I state that an audio support is also a text, therefore I consider here audio texts in the same way as written sources. They are all important for the study of the realization process and its development. In most of the cases, audio sources are fundamental for the analysis of the assembling because they demonstrate the various versions. Because my philological investigation attempts to understand the assembling process, for each source I cite its duration when indicated, which will be the most important dimension for the development of the analysis. Of course, the audio physical source itself does not reveal much more than its physical evidence. For its signal analysis (e.g., its duration), it is necessary to pass through external software for the editing of music: In this case I use Cool Edit Pro software, version 1.2. The witnesses are divided into written and audio texts; for each part, the material is organized in chronological order according to the date of publication or diffusion of the source, not to its creation. The first part lists the witnesses (textual analyses, articles, graphical analyses) in the literature completely dedicated to the piece or, if part of a book, particularly significant for its dissemination. The second column lists audio sources and printouts of the computational data. All witnesses are authorized sources that are produced by Mr. Chowning himself or accepted and partly controlled by him.

I compare at the same time audio and written documentation, because I am interested in the pure timing data to reconstruct the history of the "compositional" process of the piece—intended as assembling of sections rather than synthesis. Five

possible durations of the piece are shown: The longest duration is 18 minutes (*DJ*); the second-longest is 17'26" (*IRdig*); the third duration, 16'56", corresponds to the CD version by Wergo (*WER*, also cited in *RD*); the fourth lasts 15'46" (*TbM1* and *4-ch*); the last is 15 minutes (*IR*). The presence of two durations in the same article (*RD;* see Doati 1988) is an indication that at least two versions of *Stria* have co-existed. Some of these sources, such as *TM-LK*, are worth being presented even if not directly useful to the analysis of different durations, because they help by adding information to the historical circumstances. *IR-ta* is still a problematic source.

Other sources—some of them unpublished—partly or completely dedicated to *Stria* include Baudouin (2006), Borghesan (2005), Bossis (2005), Boulez (1980) (audio recording), Chowning (1977b), Chowning (2005a), Chowning (2005b), Dahan (2001), Gayou (2005), Means (2005), Meneghini (2003), Risset (1988), Risset (2001), Risset (2005), Roads (1985), and Schœller (1986), as well as Johannes Goebel's liner notes accompanying the Wergo recording (Chowning 1988). These have been useful from time to time for their historical, aesthetic, technical, or analytical aspects, but not directly used in my philological research on the assembling of the piece.

Description of the Sources

Toby Mountain's Graphical Score (*TbM1*)

I did have knowledge of Toby Mountain's notational representation from an unpublished musicological analysis made by the Italian composer Roberto Doati, in 1988 (Doati 1988). The analysis ends with Mr. Mountain's score, which considers a duration of 15'46". An introductory page not shown here explains that the score was produced solely from aural observation without the use of program data. In this sense, it is intended to accompany the tape and to be a general guide for the listener (underlined in the text, *TbM*1). Figure 1 shows the graphical score.

In 1980, Toby Mountain was a graduate student in music composition at the University of California, Berkeley, and received his PhD in 1981. The *Stria* analysis was part of his thesis. Mr. Mountain's analysis tends to translate the pitch information of the electronic piece into traditional notation.

Toby Mountain's Sketches for the Analysis (*TbM2*)

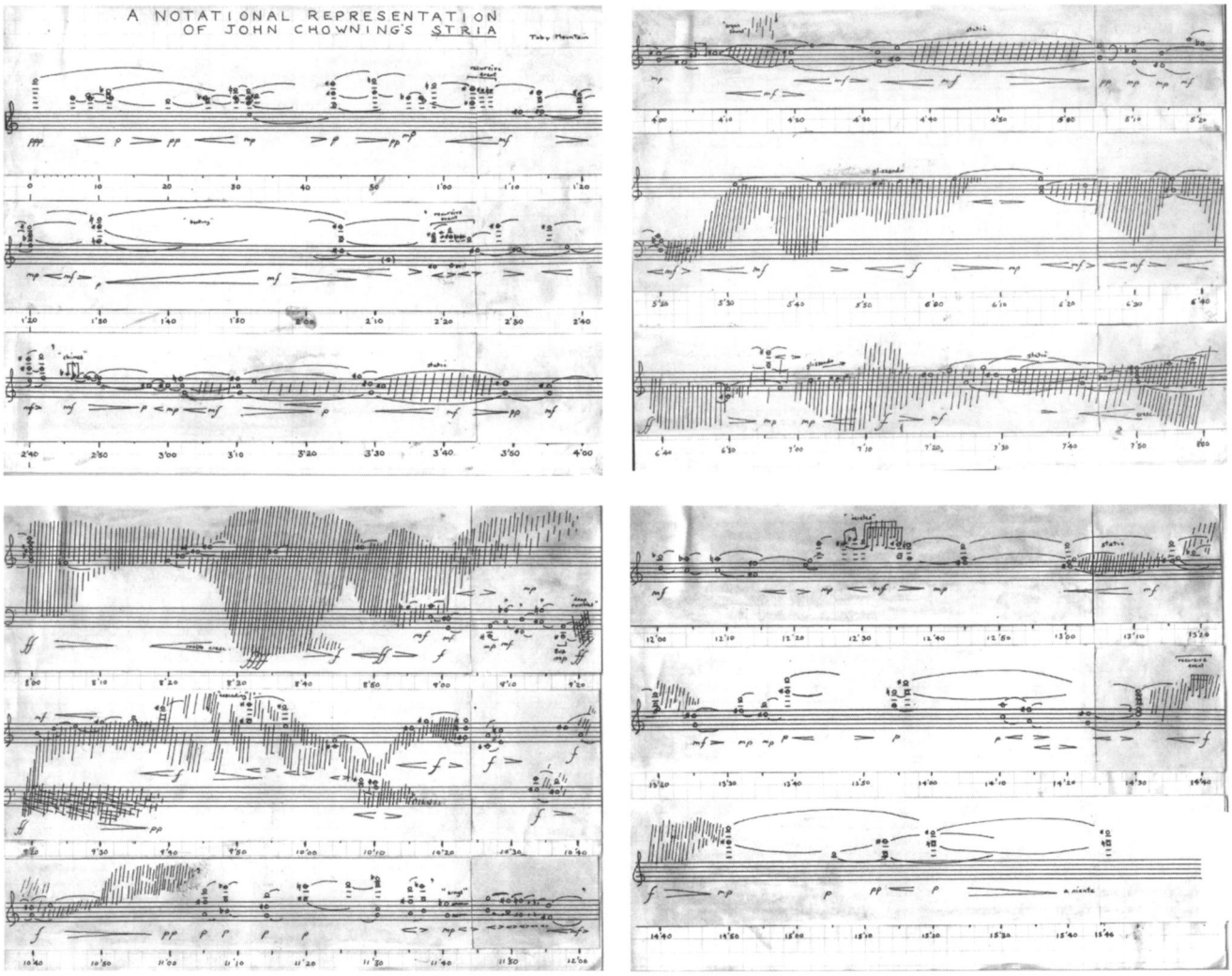
Toby Mountain kindly gave me 17 digital copies of sketches he did for the analysis of the piece (Mountain 1980). Four of them include the original graphical score of Figure 1. All of these sketches are undated. This fact sometimes poses analytical problems, because the details regarding the sections of the pieces diverge. Nevertheless, they are very useful because they show some aspects that are lacking in other sources.

Tod Machover and Lev Koblyakov (*TM-LK*)

In August 1984, Tod Machover wrote a short text for IRCAM's internal documentation of research in which he describes Mr. Chowning's work. The document is important because it specifies the research period, as it was formally documented at the French center ("Date of Project: Proj.1: 1976; Proj.2: 10/78 to 7/79", where the first period is for *Stria* and the second for *Phoné*). It also says that *Stria* is one of IRCAM's first commissions, even if the work itself was produced at Stanford and not at IRCAM. Mr. Machover complains about the lack of any serious analysis dedicated to the piece at that time "and Lev Koblyakov's short article can only serve as a basic introduction" (Machover 1984, p. 17).

Mr. Chowning himself contacted Lev Koblyakov to learn where to find the analysis to which Mr. Machover refers. Mr. Koblyakov remembers a meeting with Mr. Chowning in Spring 1979, when he was invited by Pierre Boulez to give a series of lectures on the evolution of music in the 20th century (Chowning 2005c). Mr. Chowning showed at that time some "programs for *Stria*," but he did not give them to Mr. Koblyakov. Afterward, in 1984, Tod Machover invited Lev Koblyakov to write an essay on the piece, but the article was never published. He unfortunately cannot recover the article since he moved from Jerusalem (Koblyakov 2005).

Figure 1. Toby Mountain's notational representation of Stria *(Mountain 1981).*



Another important note in Tod Machover's article says that no score exists and that most of the composer's data is no longer available. He also adds that "one is left only with the possibility of doing an aural analysis of the piece, which is virtually impossible at any but the most superficial level, since the piece deals entirely with gently shifting inharmonic spectra generated by frequency modulation" (p. 17). Even if Mr. Machover's text does not show any description of the piece and its duration, this source is important, because it states that he did not have the ability, in 1984, to look up the computer data. This means that original digital data was removed from IRCAM (or got lost after the first performance), where John Chowning remembers he left a copy of everything (Chowning 2006).

Dodge and Jerse's Scheme (*DJ*)

The famous book *Computer Music* published in 1985 by Charles Dodge and Thomas Jerse discusses the composition as well. The passage related to *Stria* very briefly explains the use of the Golden Mean, the frequency space, and the overall shape of the piece. The well-known scheme illustrated in

Figure 2. The scale compositional structure of Stria *(Dodge and Jerse 1985, p. 126).*

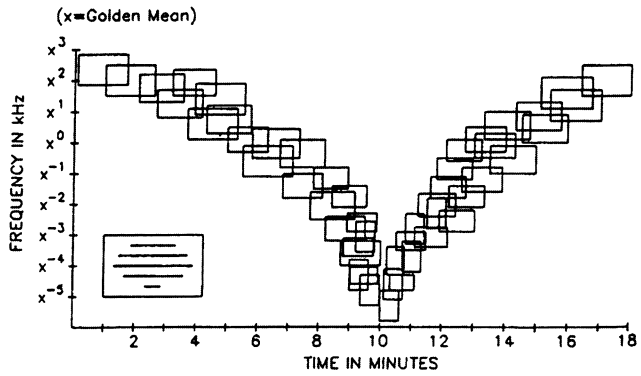


Figure 2 shows different blocks, one of which is shown in the insert to the figure, representing a number of tones that enter in temporal Golden Mean proportions. Dodge and Jerse consider this figure a sketch of the shape (without any claim to be precise in details) of the 18-minute piece. They describe the general sonority with predominantly long sounds, with an almost complete absence of percussiveness. Even though there are some changes in location of the sound, the movement is very gradual.

Roberto Doati's Analysis (*RD*)

In 1988, Italian composer Roberto Doati analyzed *Stria*. This was the first analysis of the piece (unfortunately never publicly diffused) focused on technical aspects and on original handwritten documentation by John Chowning (use of the Golden Section, FM instruments, and spectral space divisions). At the beginning of his text, Mr. Doati remarks that the duration of the four-channel tape he possesses, given by Mr. Chowning himself, is 15'46", while the CD version (he refers to the Wergo CD), has a 16'57" duration (Doati 1988). He does not give any explanation of this discrepancy. The paper develops a technical analysis of the spectral space and the general use of the Golden Mean in the piece. The last part presents an analysis of the listening with segmentation using some auditory images. In the last pages, Mr. Doati shows Toby Mountain's graphical score to support his own listening.

IRCAM's Web Site (*IR*)

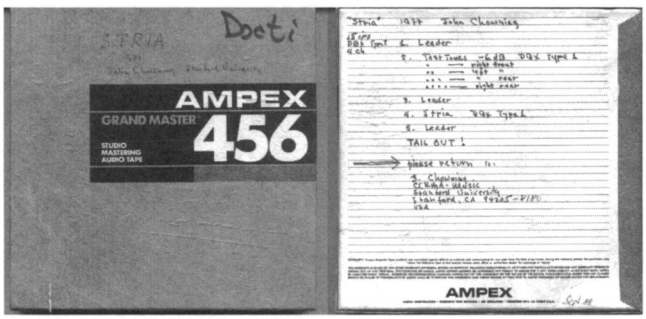
The IRCAM Web page devoted to *Stria* indicates a 15' duration. The page briefly introduces the piece and reveals some difficulties in the demonstration of the compositional aspects by means of traditional analytical tools. The unknown author of the article regrets the "impossibility" of analyzing the presence of the Fibonacci series. Moreover, the author finds it impossible to trace the Golden Mean in the overall spectrum, even employing a computer program to analyze two different sequences of the first sequences of the piece. Nevertheless, the IRCAM analysis succeeds in finding some regularity in the beginning of some adjoining spectra and in their durations. (For example, after 0'55", there is a clear changing of spectrum.) The macro-proportions are difficult to find: It is possible, however, to identify the main powerful climax in the middle of the piece (from 8'00" to 9'00"). Although it does not mention the version analyzed, this element of the article would relate it to the four-channel version (as one could easily see later in Figure 14). According to the analysis, the overall form seems to be an arch. This short article does not make use of technical information nor quote any other analyses of the piece.

Four-Channel Tape and CD-ROM (*4-ch*)

Roberto Doati kindly provided me with a CD-ROM with a recent digitization of the four-channel tape, dated September 1988, that he used for the analysis of the piece (Doati 1988). Figure 3 shows the tape box. Mr. Chowning personally sent him the analog tape (Doati 2005). The text on the box was written by Mr. Chowning himself and testifies to the presence of four sounds (Test Tones) for testing right and left, and front and back loudspeakers for performance in concert (–6 dB, DBX type 1 noise reduction).

The digitization itself was made in November 2002 by Alvise Vidolin from the analog tape. To do this, Mr. Vidolin "cooked" the four-channel Ampex Grand Master 456 tape (which had a dBx type 1 noise reduction) and then played it back on an OTARI four-channel recorder belonging to Centro di Sonologia Computazionale (CSC) dell'Università

Figure 3. Box of Mr. Doati's original four-channel tape.



di Padova, connected to a Kyma system (Capybara 320) equipped with an eight-channel, 24-bit audio interface.

Wergo CD (*WER*)

The booklet of the Wergo CD indicates a 16'57" duration. The track is stereophonic, which means that a conversion from quadraphonic to stereophonic format had been made. Nevertheless, the difference of one minute between this and the four-channel version is remarkable, indicating the presence of other important processes during CD mastering that must be studied.

The liner notes by Johannes Goebel provide brief technical explications of the compositional technique: the "original quadraphonic version utilized 12 bits, two different sampling rates being used to accommodate the enormous amount of data on the magnetic disc-packs available at that time. The original sound-data was processed by sampling-rate conversion and digital mixes to achieve the stereo version presented on this CD." The master tape of the CD "was made directly from the computer system at CCRMA which generated and stored the sound data to digital format. No analog recording was involved at any stage of the production and editing process" (Chowning 1988).

There follows an interview with John Chowning where the composer explains the genesis of the piece, his work with Andy Moorer—who showed him how to write a program in SAIL, and the fact that all was absolutely deterministic. "There is not a random number generator in that piece, which is not true of *Phoné* or *Sabelithe* or *Turenas*" (Chowning 1988). Mr. Chowning concludes that the "idea of *Stria* was initially an aural phenomenon, but then it became an intellectual one which led my ear further than I possibly could have heard."

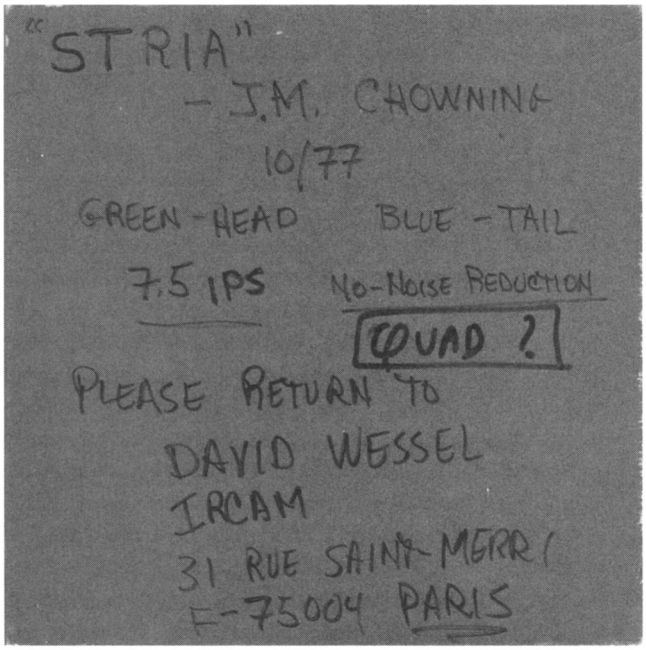
The IRCAM Tape (*IR-ta*)

This is a problematic source. Marc Battier kindly gave to me this tape, the cover of which is shown in Figure 4, which originally belonged to the IRCAM archives. Unfortunately, I have not been able to digitize the tape yet. Because it is thirty years old and the magnetic surface is deteriorating, it requires a professional procedure with several cookings before the digitization. In any case, a short listening of the very initial seconds of the tape (necessary to understand the physical condition of the tape) made it possible to identify the beginning of some 440-Hz sinusoids used for testing the loudspeakers. This means that the tape could be quadraphonic, and maybe it is a copy of the four-channel tape. This is not immediately evident, as the box shows the inscription "quad?" Further research will be essential to complete the identification of this source. Moreover, it is not possible to deduce the duration of the tape without listening to it. No dating is marked on the box, except for the date of realization of the piece, which of course does not directly correspond to the realization of the tape. Other technical characteristics of the tape, as indicated on the box, are the following: "green head, blue tail, 7.5 ips, no-noise reduction."

IRCAM Digitization (*IRdig*)

This is a four-channel digital version on CD-ROM provided by John Chowning. It probably is a copy of the digitization of the four-channel tape (*4-ch*). However, the CD-ROM does not show any note on the box, nor does the composer remember who made the original digital version of the four-channel tape of *Stria*. This must be verified. (According to Mr. Chowning, it was not he who made the digitization.) He is also "sure that it is not assembled from the digital files that Johannes [Goebel] used to make

Figure 4. The IRCAM four-channel (?) tape.



the Wergo recording, because I would have been involved." The sampling rate of the four tracks is listed at 44,100 Hz at 16-bit quantization, and the overall duration is 17'26". As will be demonstrated in the following section, the source had been digitized at a sampling rate of 48,000 Hz, causing a difference in its duration easily adjustable by sampling rate conversion.

John Chowning's Digital Data (*JCdig*)

These are sources scanned from paper printout of the digital data and from various other documents, some of them handwritten, used for the synthesis and the calculation of the structure of the piece. They originally belonged to Mr. Chowning's personal archive and are, since 2007, stored at Stanford University Archives in the John Chowning Papers. Among them there are eight different files dating from 27 September 1977–3 October 1977. Each file shows the date, the precise hour of the calculation job (e.g., 4:48, 14:33, 21:48, etc.) and the date of "printing," which is important to understand working hours of the author. Each file shows the signature [PC, JC],

Figure 5. Header of JCdig *files (in this case,* `T0.MEM`*).*

```
Name: John Chowning

Project:   PC        Programmer:   JC

File Name: T0.MEM[ PC, JC]

File Last Written:   4:48 2 Oct 1977

Time:  9:36          Date: 5 Oct 1977

          Stanford University
     Artificial Intelligence Laboratory
       Computer Science Department
          Stanford, California
```

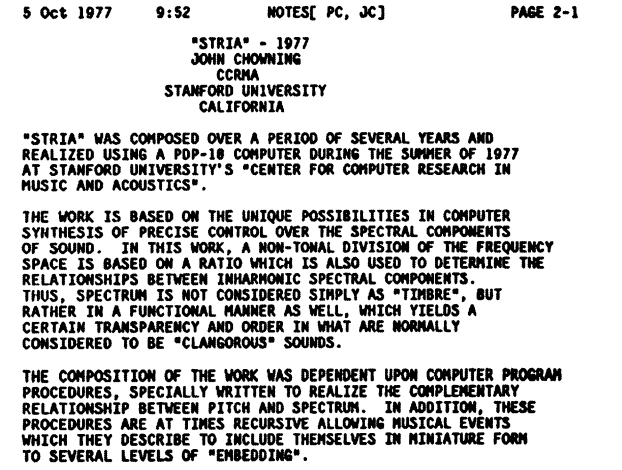
which stands for "made by John Chowning and stocked in a personal area of digital memory at the Artificial Intelligence Laboratory" (see Figure 5).

JCdig sources used for my research are of seven types:

1. The first, `COMP.SAI` (one file) dated 3 October 1977 and `COMP.SAI` (one file), dated 7 January 1978, consist of algorithms for the generation of the piece (Chowning 1977d, Chowning 1978a).
2. The second one (six modules named `T0.MEM`, `T286.MEM`, `T466.MEM`, `T610.MEM`, `T754G.MEM`, `END.MEM`) print a record of input values requested by `COMP.SAI` and various data that have been inserted. `MEM` files are records of data used for the generation of each section of the piece (Chowning 1977a).
3. Next, one file (`T0.SCR`), dated 26 September 1977, is the "score" that the program `COMP.SAI` generates. The file includes a series of parameters for the synthesis of sound (another type of file generated by the program—with extension `.REP`—appears among different data but was not used; this was probably a report file for incidental errors, or perhaps it is a lost file) (Chowning 1977c).
4. One file, dated 8 September 1977, is named `CPC4.INS`, with algorithms for the instrument (Chowning 1977b).
5. Another file, dated 5 January 1978 and named `CPC4.INS`, includes algorithms for reverberation (Chowning 1978b).

6. Another source includes a file with program notes for the first performance, dated 5 October 1977 (Chowning 1977e).
7. The next source includes two undated (most likely 1977) handwritten notes indicating various sampling rates for sections (Chowning, 1977(?)a) and the formal scheme of the piece (Chowning 1977(?)b).

Other sources are included on the forthcoming *Computer Music Journal Sound and Video Anthology* DVD that accompanies issue 31:4.



5 Oct 1977 9:52 NOTES[PC, JC] PAGE 2-1

"STRIA" - 1977
JOHN CHOWNING
CCRMA
STANFORD UNIVERSITY
CALIFORNIA

"STRIA" WAS COMPOSED OVER A PERIOD OF SEVERAL YEARS AND REALIZED USING A PDP-10 COMPUTER DURING THE SUMMER OF 1977 AT STANFORD UNIVERSITY'S "CENTER FOR COMPUTER RESEARCH IN MUSIC AND ACOUSTICS".

THE WORK IS BASED ON THE UNIQUE POSSIBILITIES IN COMPUTER SYNTHESIS OF PRECISE CONTROL OVER THE SPECTRAL COMPONENTS OF SOUND. IN THIS WORK, A NON-TONAL DIVISION OF THE FREQUENCY SPACE IS BASED ON A RATIO WHICH IS ALSO USED TO DETERMINE THE RELATIONSHIPS BETWEEN INHARMONIC SPECTRAL COMPONENTS. THUS, SPECTRUM IS NOT CONSIDERED SIMPLY AS "TIMBRE", BUT RATHER IN A FUNCTIONAL MANNER AS WELL, WHICH YIELDS A CERTAIN TRANSPARENCY AND ORDER IN WHAT ARE NORMALLY CONSIDERED TO BE "CLANGOROUS" SOUNDS.

THE COMPOSITION OF THE WORK WAS DEPENDENT UPON COMPUTER PROGRAM PROCEDURES, SPECIALLY WRITTEN TO REALIZE THE COMPLEMENTARY RELATIONSHIP BETWEEN PITCH AND SPECTRUM. IN ADDITION, THESE PROCEDURES ARE AT TIMES RECURSIVE ALLOWING MUSICAL EVENTS WHICH THEY DESCRIBE TO INCLUDE THEMSELVES IN MINIATURE FORM TO SEVERAL LEVELS OF "EMBEDDING".

Figure 6. Stria *program notes by John Chowning (Chowning 1977e).*

Comparative Evaluation and First Hypothesis

Philological investigation has passed three steps thus far: analysis of the sources; comparison among them; and comparison with external testimonies including oral witnesses, electronic mail, and various schemes and figures that John Chowning, the authors of the other sources, and people involved in the assembling process sent to me, in order to help my quest for the history and the circumstances involving the realization of *Stria.*

What follows are some reflections related particularly to the historical circumstances that bred the sources. A common point of reference is the overall duration of each source. I must emphasize the blurred digital–analog nature of the piece, which also characterizes each piece of computer music realized during this historical period: Namely, data were digitally calculated but then fixed on an analog recording. That justifies the congenital "imprecision" within the digital–analog conversion (or copy from tape to tape) and, consequently, some inaccuracies in analog audio sources (or their recent digitization) and their comparison.

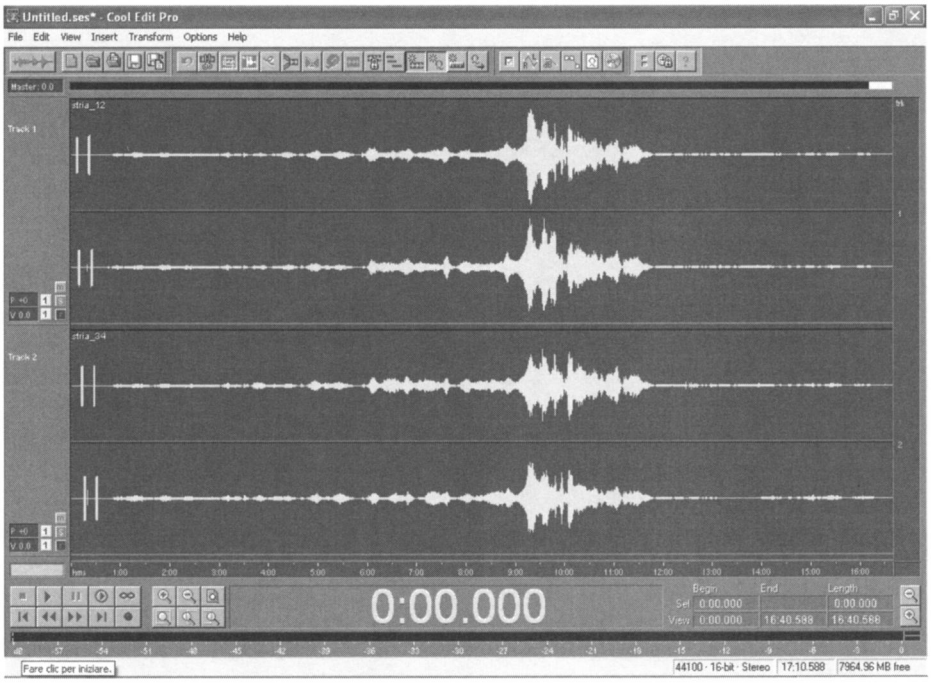
For what concerns the *TM* source, Tod Machover writes that the project of *Stria* was developed in 1976. This is the unique case where that date appears. John Chowning always declares, in his oral and written sources, he worked during the summer of 1977. But he also explains that the piece was on his mind for some years: in Berlin during 1974–1975 (according to Johannes Goebel's liner notes accompanying the Wergo recording, p. 12), "over a period of several years," as he writes in the program notes for the first performance in Figure 6—and it may be that IRCAM asked him to do the piece in 1975 or 1976 according to the composer. He also stresses that the title came to his mind toward the end of its realization (during Summer and Fall 1977).

The *TbM1* source attempts to translate the piece onto traditional notation. The perceptual representation starts with long and high sounds. At 5'20", the first fall to low sounds occurs. From 8'00" to 10'10", there is a continuous thickening of spectra with low sounds. This differs from Dodge and Jerse's structure (*DJ*) which puts this climax at 10'00". This source does not reveal any low notes at 5'20". Probably, the *DJ* analysis was based on the digital data. So the difference in the spectral space ought to depend on the bandwidth of each modulated sound, which makes perceptive listening differ from the pure computer data, but also from the different durations.

John Chowning explains that Mr. Mountain's transcription (15'46" duration), is almost certainly from copies of the *Stria* version that the composer reassembled at IRCAM the day following the first performance, on 14 October 1977, and brought back from Paris to CCRMA. This would relate the *TbM1* analysis to the *4-ch* analysis.

Figure 7 shows the amplitude/time representation of the four-channel tape (*4-ch*) and the four-loudspeaker arrangement (as deduced from *RD*). The amplitude-time representation of the piece lasts

Figure 7. Amplitude-time representation of the four-channel tape (4-ch). Channel 1 is front-right, 2 is front-left, 3 is rear-left, and 4 is rear-right.



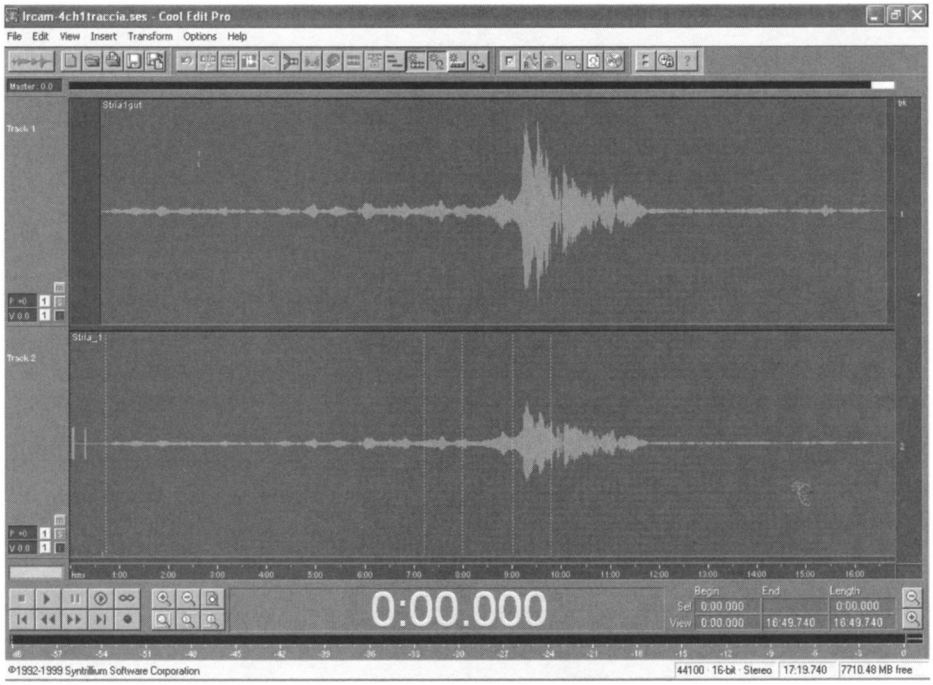
16'40". This happens because the digitization of the tape (and the tape itself) begins with 28 sec of four groups of sinusoids at 440 Hz. The piece begins at 0'44" and ends at 16'32". (Here, the track contains a click followed by low hiss.) The piece is thus 15'48" duration, which presents a quite negligible error of 2 sec compared to 15'46" cited in Doati (1988) and probably caused by rounding the timing up.

Comparison between Mr. Mountain's graphical score and the listening of Mr. Doati's four-channel tape suggests that this one and what Mr. Mountain analyzed are the same, as it appears from harmonic comparison through listening and from the durations. Now, according to what John Chowning says about the Mountain analysis—namely, that that was the version mixed the day following the first performance—we can therefore establish that Mr. Doati's four-channel tape corresponds to the "CCRMA version" (also confirmed by the composer; Chowning 2005c).

Toby Mountain kindly provided me with extra notes he used for his analysis (*TbM2;* Mountain 1980). He says that all these notes were based on conversation with Mr. Chowning and his explanation of the piece and that "almost none of those notes represent original thinking on his own part" (Mountain 2005). But they are very useful for my analysis because they show some problems on number, names, and durations of the sections that illuminate the compositional process.

IRCAM's digitization (*IRdig*) of the four-channel tape is problematic. The four audio files' properties show a sampling rate of 44,100 Hz with 16-bit quantization, and their duration is 17'26". Nevertheless, aural inspection reveals that the overall sound of the piece is lower (more or less a semitone) than the four-channel source. That means that the original digitization had been made at a 48,000-Hz sampling rate. Adjustment of the rate from 44,100 to 48,000 Hz and conversion again from 48,000 to 44,100 Hz lowers the duration to 16'01". Considering an easy reject in the reading and differences in initial and final silences of the tracks, this duration is comparable to *4-ch* (15'46"). The waveforms are similar, as is demonstrated in Figure 8, even analyzed and deeply zoomed more carefully with Cool Edit software. *IRdig* does not start with four tests for the loudspeakers.

Figure 8. IRdig *first channel versus* 4-ch *first channel.*



(To complete the historical scene, it is worth noting that Pierre Boulez spoke about *Stria* for a Radio France broadcast lecture on 22–28 April 1980 at the Théâtre d'Orsay, Paris; [Boulez 1980]. The excerpts from *Stria* are played at the proper pitch. This demonstrates that the *IRdig* source, the digitization of the analog tape, was made after 1980 when this cassette was made. The fact that he played only a few excerpts unfortunately does not permit us to deduce if this was the first long IRCAM version.)

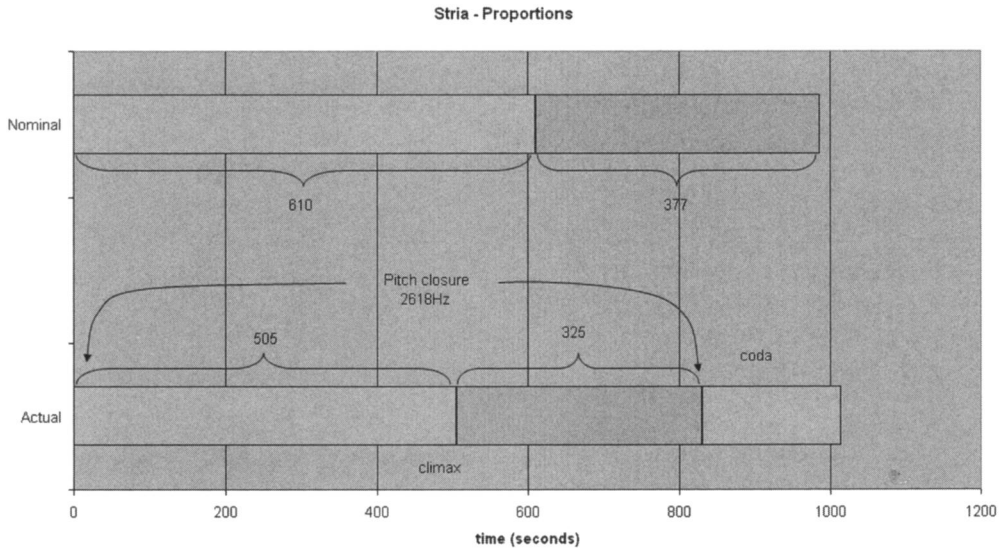
I can state that the IRCAM digitization (*IRdig*) does correspond to the four-channel source, or that concerts at IRCAM normally played the "false" version a half-tone lower in pitch.

DJ (Dodge and Jerse's famous scheme) registers the longest time duration. Why does this scheme attach an 18-min duration to the piece? Mr. Chowning notes that this scheme is conceptual rather than actual (Chowning 2004). He remembers having told Charles Dodge that the duration was 18'00", forgetting that he had shortened *Stria* in the process of reassembling. And he also remembers that the first performance was even more than 18'00" in duration, which gives us again a sixth time duration. (This would mean that the IRCAM version was closer to 18'00", rather than 15'00", as their Web site indicates.) Mr. Chowning says that Mr. Dodge asked him

> to join him for a short time in a café after some event somewhere on the East coast. I explained the basic scheme of *Stria,* the relationship of the golden section to the spectra and pitch space, the formal division 610/987 (16'27" = 987) being the Golden Section, and how I composed it by developing a recursive procedure. He did not ask for any material. Their book was published in 1985. So they did not have the Wergo CD either, and I have no knowledge of their having a copy of the tape, although they may have. Perhaps they heard it at the ICMC at UCSD (Chowning 2005c).

At IRCAM, it seems impossible to find any documentation, written or audio, of the first version or any digital data left (as *TM-LK* informs). My research on the very first version (IRCAM's first performance) stops here concerning audio sources.

Figure 9. Nominal version large-time divisions versus the actual version (Chowning 2004).



Assembling Process

My investigation on the assembling focuses therefore on *4-ch* and *WER* audio sources. I have already pointed out that Mr. Doati's four-channel tape and the Wergo CD differ by about 1 min; this is a very important divergence, and their waveforms are in some points different. It is important to note the electroacoustic community has never been bothered by this difference in timing.

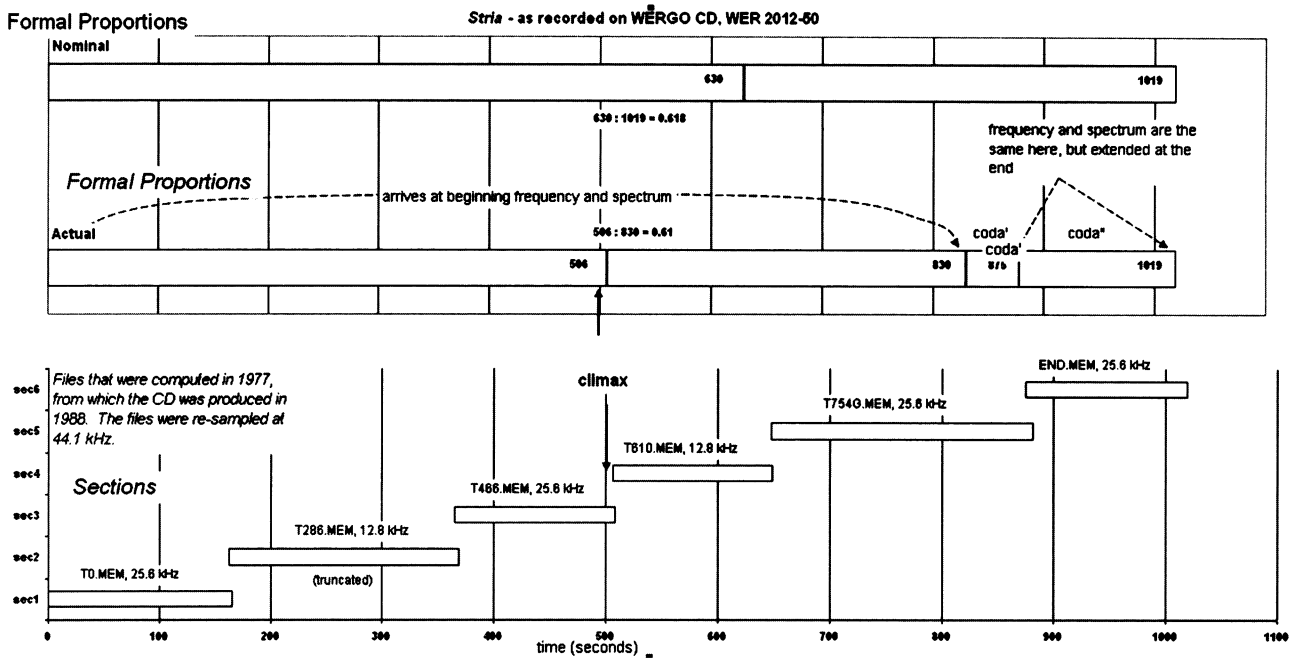
At the beginning of my research, Mr. Chowning himself explained that such differences were caused by the new mixing realized for the CD, but he did not recall the precise circumstances that caused this important change. Nevertheless, he initially provided me with some Excel files that tried to explain all the passages. Mr. Chowning also declared that some differences from his ideal sketches (perhaps the IRCAM version or some previous sketches?) and the actual piece of music exist. The nominal shape is

> what was in my head (classical geometric division), but music, of course, is not sensed only in metered time (and certainly not *Stria*). There are so many factors such as density, loudness, pitch height, duration, etc., of sound, so what was composed is what was in my ear relative to the abstract geometric model. Where exactly the climax occurs is still a mystery to me as it is a region. The nature of the piece does not really suggest points. I only know that it is before 8'25", and at 8'25" there is a kind of sectional closure (Chowning 2004).

Figure 9 shows what Mr. Chowning intended, in 2004, as a nominal version large time divisions of the piece and an actual one (Chowning 2004). The nominal version is the composer's first intention, that is the classical Golden Section division. (Note that 1.6180 is the actual ratio of the values 987:610:377.) Nevertheless, no duration of my documents matches the overall duration of this nominal version (16'27").

Mr. Chowning then indicates what he intended to be the "actual" version. This is a bit longer (16'54"). The proportions are modified but closer to the Wergo CD duration, which is 16'56". A coda is added from 8'30", and the sections in some cases follow the Golden Mean (830:505 = 1.643). It is also clear, at this point, that Dodge's and Jerse's diagram (*DJ*) has totally different proportions (18'00") relative to all other versions. If one takes this schema for granted, *WER* could be the version that better satisfies the actual version, but this invalidated by the next considerations.

Figure 10. Assembling of Stria *as recorded on the Wergo CD versus nominal and actual versions (Chowning 2004).*



This document differs from the one published by Bruno Bossis in 2005, which shows an original (nominal) version with two blocks (630"—389") and an actual version made by two sections (506"—324") and a coda (Bossis 2005, p. 101). Trying to explain these discrepancies, in another later Excel file, Mr. Chowning compares the Wergo audio version with the four-channel tape and the actual version (see Figure 10), trying to rebuild his own compositional process. "I have made myself go back and try and remember what I did in 1977 and 1988 when the CD was produced. This is what I have reconstructed from the `*.mem` files and the CD recording. I remember now that I truncated the second section, but never modified the data" (Chowning 2004). The nominal and actual versions have here the same duration (16'59" = 1,019 sec): the Wergo version lasts 17'00" (1,020 seconds), quite close to the audio Wergo version (*WER*), which lasts 16'56". This also slightly differs from the actual version in Figure 10 (1,014 sec, 16'54"). Figure 10 is also presented in Bossis's article (Bossis 2005, p. 102).

These were Chowning's first explanations and memories, but real durations and assembling processes need to be verified. It is useful therefore to compare (1) the computer algorithms, input data, and digital scores (*JCdig*) with (2) the Excel files with schemes and numerical data related to the timing and (3) the audio files.

According to Figure 10, *Stria*, in the Wergo version, is shaped in six sections, some of which are slightly overlapping. These are `T0.MEM`, `T286.MEM`, `T466.MEM`, `T610.MEM`, `T754G.MEM`, and `END.MEM`. The number after `T` indicates the time of initialization.

Each section corresponds effectively to the data listings *JCdig*, with the `.MEM` extension representing the input to the `COMP.SAI` procedures. `T0.MEM` was sampled at 25.6 kHz, `T286.MEM` at 12.8 kHz (an important note in Figure 10 says "truncated"), `T466.MEM` at 25.6 kHz, `T610.MEM` at 12.8 kHz, `T754G.MEM` at 25.6 kHz, and `END.MEM` at 25.6 kHz. (The same sampling rates are shown in Figure 18, handwritten by the composer.)

Table 2 shows different initialization time of the six sections (`Tx.MEM`), as indicated in the *JCdig* computer data. The end of the listing of each `.MEM` file shows the complete value (in sec) of each section ("Duration"). Each file also indicates the timing of the printed output; with the exception of

Table 2. Mr. Chowning's .MEM Files

Computer Data

Section	*Duration*	*File last written*
T0.MEM	166 (2'46")	4:48, 2 October 1977
T286.MEM	325 (5'25")	2:37, 3 October 1977
T466.MEM	144 (2'24")	7:21, 27 September 1977
T610.MEM	144 (2'24")	17:53, 29 September 1977
T754G.MEM	234 (3'54")	0:41, 3 October 1977
END.MEM	145 (2'25")	4:45, 3 October 1977

T610 calculated at 17:53 (i.e., 5:53 PM), the other sections were realized at night. Mr. Chowning clearly demonstrated the late-night work ethic attributed to many computer music pioneers with "heavy eyelids," who were forced to work at night owing to policies limiting the use of the PDP-10 for music and the very long calculation time owing to time-sharing.

The synthesis instruments were in the form that was established by Max Mathews (1969), which consisted of unit generators that synthesised and controlled the acoustic signals. COMP.SAI included the algorithms and generates three different files: x.SCR (the score), x.REP (never used), and x.MEM. The file T0.SCR is the only complete set of instrument and reverberator data. The .SCR file consisted of the time-ordered parameters that were passed to the synthesis algorithms. The parameters of the .SCR file were the start times and durations of the instruments, the frequencies of the FM oscillators, the name of the functions used for amplitude envelopes and frequency skew, the angular and radial position of the instrument output, etc. (Chowning 1977d).

It is clear from Table 2 that initialization times compared to durations do not always coincide (e.g., T0 + 166 sec ≠ 286). To try to explain that, it is helpful to compare all the data collected. Table 3 collates all durations marked in Figure 10 and Table 2. On the left are the data of the Excel file represented in Table 2 (Init time values are recollected by John Chowning). On the right are the timing listings as set up in the computer data *JCdig*.

END.MEM was the last file to be calculated, i.e., digitally generated but not evidently conceived; it was 4:45 AM, ten days before the first performance. Mr. Chowning adds: "In fact it was one of the first sections that I generated; as I remember it was originally T0. After much consideration, I decided that it was the perfect ending according to my evolving conception of the piece and I renamed it END.MEM (.SCR, .REP)." This is also confirmed by the relatively few input parameters for an earlier form of COMP.SAI (Chowning 1977d, 2006, 2007).

The x in the T.MEM files (0, 286, 466, etc.) stands for the time initialization (in seconds) and uses Fibonacci numbers. Fibonacci numbers (beyond the synthesis of the frequency space) are used in *Stria* to determine start times, attack durations (the time within which elements can begin within an event), and overall durations. However, Mr. Chowning explains that the values are not always simple Fibonacci numbers, but additions of the numbers taken from the series, for example 466 = 89 + 144 + 233 (Chowning 2005c).

Table 3 shows that the x timings of the sections assembled in the Wergo version (*WER*) and those synthesised by the computer data correspond. T745g *WER* (left) corresponds to T754G; an error made by Mr. Chowning in the compilation of the Excel file reversed the numbers, but the sections are the same (Chowning 2005c).

Computer data listings and x values of the .MEM files bear traces of the removal or change of some sections: This happens for the gap between the end of T0 (2'46") and the beginning of T286 (3'26"). This could mean two things: (1) that the x.MEM numbers cannot always stand for the time initialization of each file—in fact, the time initialization of the pure x value would be 0'00", 4'46" (T286), 7'46" (T466), 10'10" (T610), 12'34" (T754G), ? (END); or (2) that the composer originally created some other sections and later deleted them, which is more probable and will be demonstrated.

All this reveals that Mr. Chowning's original project was different from its musical realization. Above all, he conceived some other sections that must stand between the ones we know, for example between T0 and T286, to cover the gap I have pointed out. The score bears out this theory. The procedure inharm—shown in Figure 11 and which is part of the COMP.SAI file—refers to some sec-

Table 3. Comparison Between Wergo Assembling (as Hypothesized by John Chowning) and *JCdig*

	WERGO assembling			*Computer data*		
Section	*Init time*	*End time*	*Duration*	*Init time*	*Duration*	*File last written*
T0.MEM	0	166 (2'46")	166 (2'46")	0	166 (2'46")	4:48, 2 Oct. '77
T286.MEM*	163 (2'43")	369 (6'9")	206 (3'26")	206 (3'26")	325 (5'25")	2:37, 3 Oct. '77
T466.MEM	365 (6'5")	509 (8'29")	144 (2'24")	466 (7'46")	144 (2'24")	7:21, 27 Sept. '77
T610.MEM	506 (8'26")	650 (10'50")	144 (2'24")	650 (10'50")	144 (2'24")	17:53, 29 Sept. '77
T745g.MEM	648 (10'48")	882 (14'42")	234 (3'54")	754 (12'34")	234 (3'54")	0:41, 3 Oct. '77
END.MEM	875 (14'35")	1020 (17'00")	145 (2'25")		145 (2'25")	4:45, 3 Oct. '77

*The original duration (325") was truncated for the actual CD (206")

tions named T466A and T377. The A after T466 was just to identify it as one of some number of versions, e.g. T466, T466A, T466B, that he tried for that section; this was similar for T754G.MEM (Chowning 2005c).

In May 2005, Mr. Chowning found another meaningful handwritten document (undated) showing that the original plan (see Figure 12) included another section named T163, which would have filled the gap between T0 and T286. In fact, the last start time of T0.MEM is 159.682", and its latest end time is 166" (data taken from the Excel file and T0.MEM). T163 would have slightly overlapped, beginning at 163". This *Stria* version is shaped in seven sections, which include T0, T163, T286, T466, T610, T754F, and END. Even the F of T754 is the only occurrence; the other important detail shown in Figure 12 is the overall duration: 987", that is, 16'27".

Mr. Chowning finally decided not to include T163 or T377 (Chowning 2005c). Toby Mountain's sketches (*TbM2;* Mountain 1980) are also revealing of this process. Mr. Mountain explains: "I think John gave me a copy of the computer printout, but I don't think I used it. My notes with the different times for the sections were based on what he told me" (Mountain 2005). One of Mr. Mountain's notes (see Figure 13) refers to six sections in the following order: T0, T166, T466, T610, T754, and END. We can see that there certainly was a section named T166 (I have decided to accept this discrepancy—T166 instead of T163 of Figure 12, which could be simply a later section with more refined instructions), but in this case, T286 is lacking, as it was an alternate section. The note is useful though, because it indicates

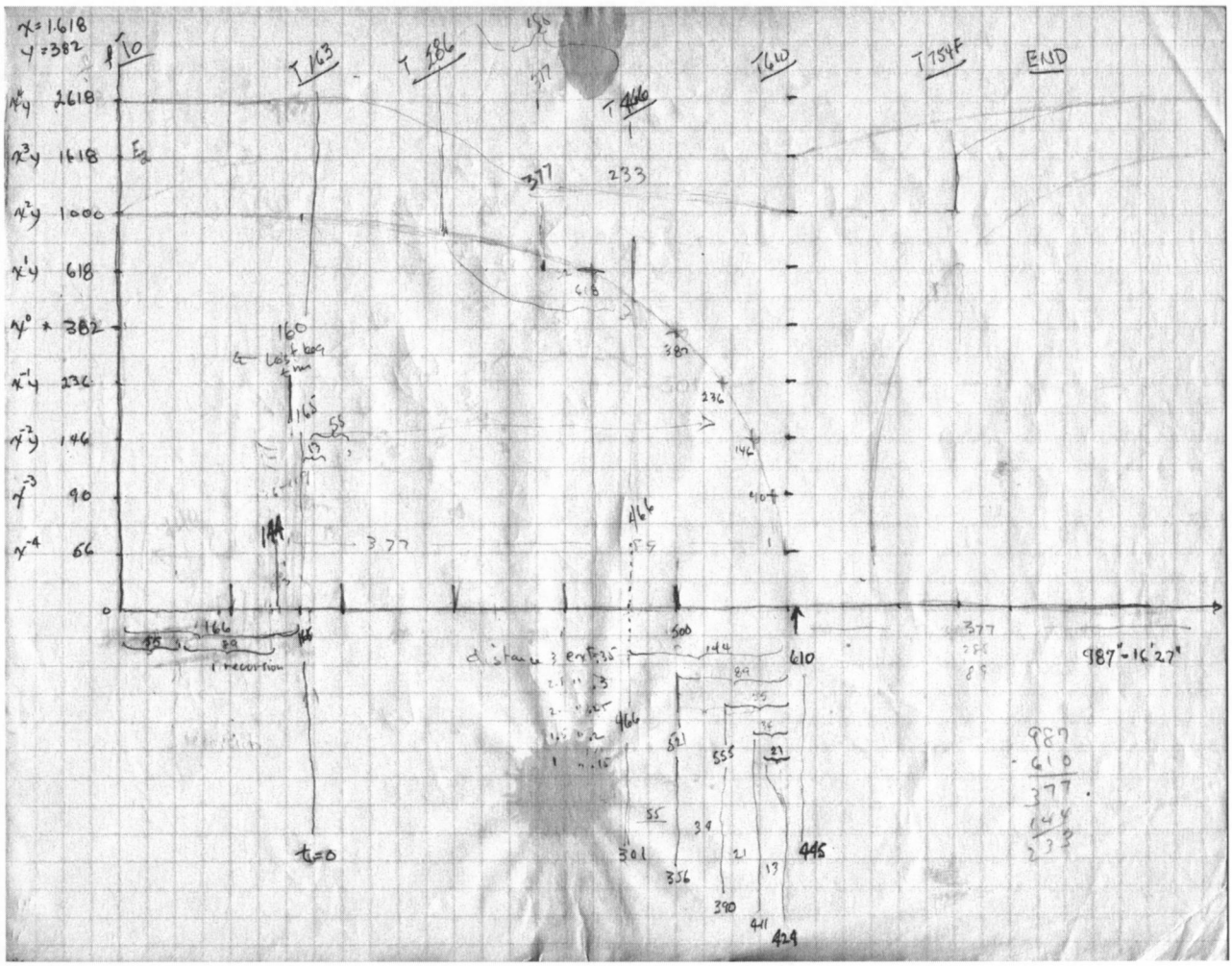
```
 3 Oct 1977    14:33          COMP.SAI[ PC, JC]

 REAL PROCEDURE inharm
        (REAL space;
 INTEGER divx,dense);
 \ inharm(space,divx,dense);

 BEGIN "inharm"
 REAL scale_freq,tes,y;
 OWN INTEGER num,k,kk,j,i,perm;
 OWN INTEGER ARRAY ftab[0:9];
 IF onc=TRUE OR CCKK = 1 THEN
         BEGIN

   ftab[0]←8;
   ftab[1]←4;
   ftab[2]←3;
   ftab[3]←8;
   ftab[4]←6;
   ftab[5]←5;
   ftab[6]←7;
   ftab[7]←9;
   ftab[8]←2;
   ftab[9]←1;

 \ The set below is used for T0-T466-T466A-T377-T610;
 \ ftab[0]←0;
 \ ftab[1]←4;
 \ ftab[2]←3;
 \ ftab[3]←9;
 \ ftab[4]←6;
 \ ftab[5]←5;
 \ ftab[6]←7;
 \ ftab[7]←8;
 \ ftab[8]←2;
 \ ftab[9]←1;
```

Figure 11. Inharm *procedure (*JCdig*; Chowning 1977d).*

the duration of T166 (268 sec) and the duration of the single events within each section.

Stimulated by these observations, the composer also remembers that the first performance still included the T166 section, which was a very static

Figure 12. Handwritten document by John Chowning (Chowning 1977(?)b).



section. T754 was the original end, but before leaving for the first performance, he added the END section, both of which end on C-sharp7. Actually, he had realized END early in composing the piece (*JCdig* indicates it was the last to be calculated for the definitive synthesis of the sections), which is why the .MEM data is shorter than the others. The program grew as Mr. Chowning developed the piece (Chowning 2005c).

Following the first performance, the composer truncated T166 and maintained six sections: T0, T286, T466, T610, T754G, and END. The truncation is quoted also by another note by Toby Mountain (in a file called note.03) which reads: "Total time 15:46, 946 sec (original 987"), Golden section 584—9:44 climax, eliminated one section" (Mountain 1980). Mr. Mountain's quotation—987 sec, or 16'27"—correspond to the version with seven sections.

At this point, I help my investigation by the listening analysis and corresponding amplitude-time representation. The comparison between *4-ch* and *WER* audio versions was made by listening carefully to the sound files. In this way it has been possible to locate where each section begins, how it sounds, and how it is mixed with the following section. The most evident element (in the time–amplitude representation) is that—as I have already remarked in

Figure 13. Toby Mountain's `note.07` *sketch (Mountain 1980).*

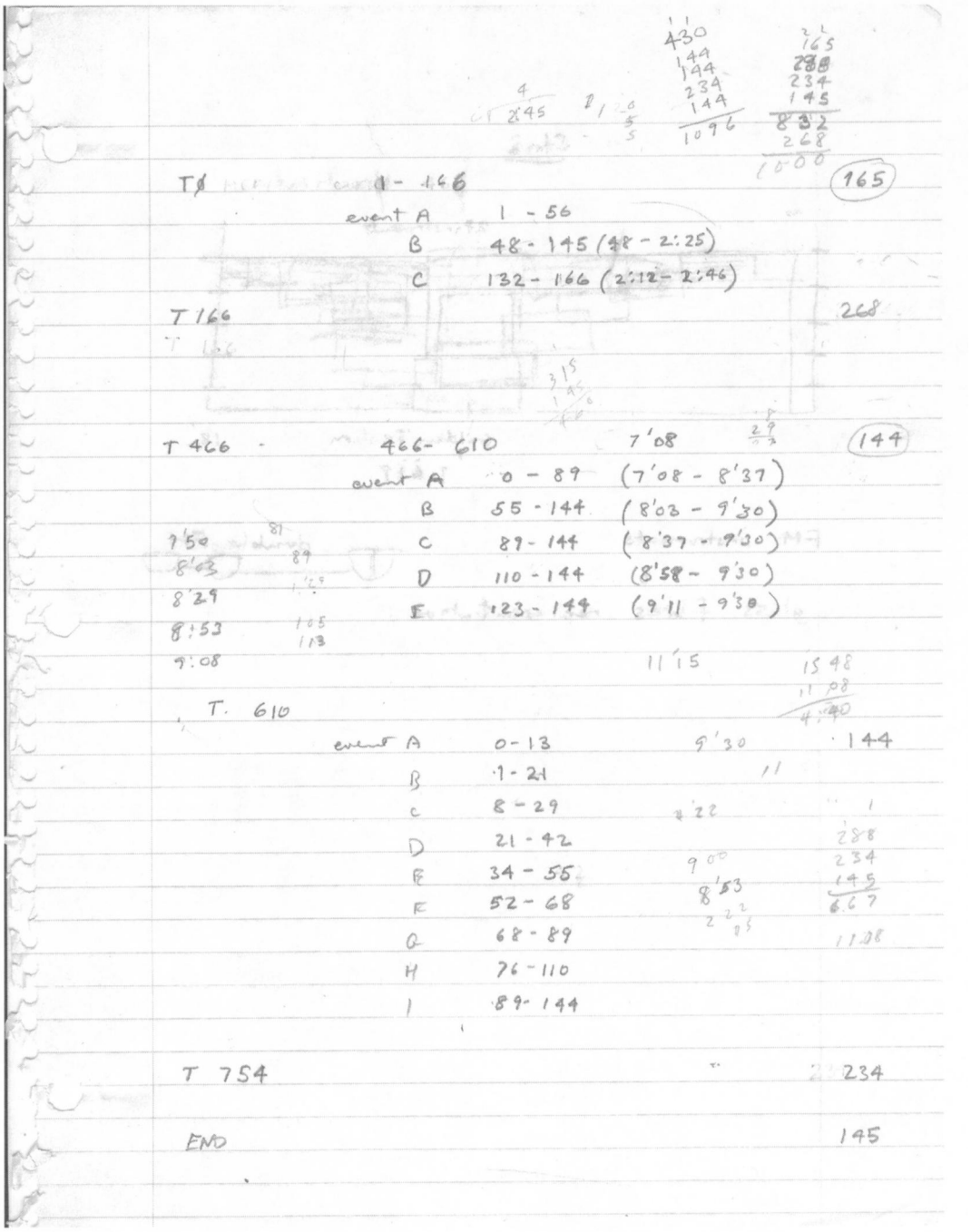
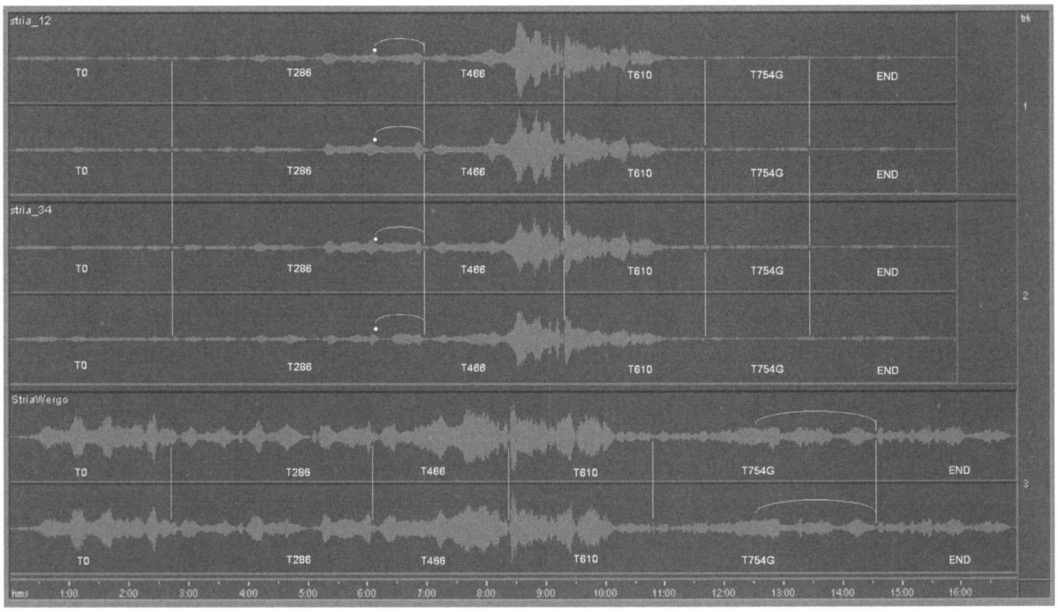


Figure 14. Four-channel tape versus Wergo version.



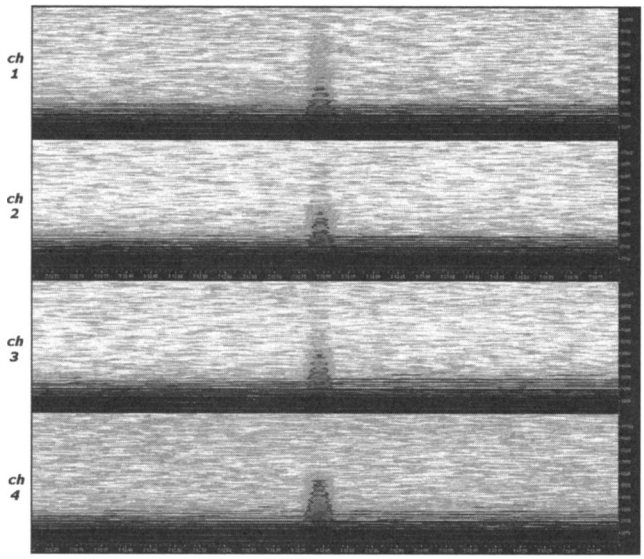
the different time durations—the four-channel tape is shorter than the Wergo version by one minute (see Figure 14).

The assembling for the Wergo CD was made by Johannes Goebel, a composer/producer/technician, on behalf of the Schott firm, of which Wergo is a part. According to his liner notes, Mr. Goebel made the CD in 1988 from the original sound files that had been transferred from the mass storage disk (perhaps Librascope, as Mr. Chowning remembers) and kept on digital tapes (Chowning 2005c).

The reason for the longer Wergo version's duration dates back to the collaboration between Mr. Goebel and Mr. Chowning. At the beginning of my research, Mr. Chowning recalled that Mr. Goebel took with him two alternative sections to the original sections (four-channel version): (1) one following 2'43", "that I had originally considered" (Chowning 2004); (2) an extended section before the end that Chowning had originally truncated when he recorded it onto tape. (At CCRMA, composers and staff never discarded sampled data, as it took hours to compute; Chowning 2005c.) When Mr. Goebel was doing this, it was a very busy time at CCRMA, so Mr. Chowning just controlled and listened to the beginning section and loud section before 8'25" to confirm levels. He did not realize that it was not the same version as the original before Johannes Goebel returned to Germany. The Wergo CD was produced with that version (Chowning 2005c). Comparing a listening to the amplitude-time representation, it is evident that (1) `T286` lasts 252 sec in *4-ch;* (2) `T286` lasts 204 sec in *WER.*

If we consider normal errors owing to imprecise selection of the audio files and the overlapping of the sections and we take into account data marked in Table 3, we can assume that (1) `T286` in *WER* lasts 206 sec (204 sec in my listening is an acceptable error); (2) in *4-ch,* `T286` lasts 252 sec, but *JCdig* `T286.MEM` indicates 325 sec. It is a remarkable discrepancy that apparently hides three steps in the history of `T286`: synthesis (325" duration), first probable truncation (252"), and third truncation (*WER*). The composer later has explained that `T286` was truncated the first time because `T286` was similar to the following `T466` (Chowning 2005c). The last four events of both `T286` and `T466` have the same durations and attack durations, with only a different base frequency (one pseudo-octave higher in `T466`). This had led him to replace all of the last

Figure 15. Discontinuity at 6'29" (389").



part of T286 with T466 (Chowning 2006). Concerning T754G, my listening reveals that (1) T754G in *4-ch* lasts 111 sec; (2) T754G in *WER* lasts 230 sec.

Because sections that Mr. Goebel did use were the original sections converted to different tapes from digital data, it is clear that: (1) T754G lasts 234 sec, as marked in Table 3, in both *WER* and *JCdig;* (2) T754G, with a duration of 234 sec, is the one originally calculated since the first writing of T754.MEM section; (3) the short T754G used in *4-ch* is a version cut down at a certain point of the realization (before or after the first performance at IRCAM).

The comparison pointed out in Figure 14 has helped Mr. Chowning remember that some of the events happened in 1977 and suggested to him why the Wergo version was cut by Johannes Goebel. (The truncated part of T286 is marked with a curve in the graph.) Mr. Chowning remembers that in the CCRMA version (*4-ch*), there was a "discontinuity" in the D/A conversion of the data at 6'29" (389") from the original computation that was unintended. This caused a sudden change of timbre and a consequent click: "[T]he PDP-10 burped!" (Chowning 2005c). This imperfection in the computation emerges slightly, but very clearly indeed, in the audio source and with a zoom of the sonogram. The discontinuity is marked by a spot in the Figure 14, and it is zoomed in Figure 15. We can see that the constant flowing of the FM spectra is broken by the discontinuity.

My listening confirms that T286 was already truncated (252 sec instead of 325 sec); in *WER,* the audio is truncated exactly at that point (6'29") with a fade out to the following section. Owing to the large amount of the computational effort involved at that time, Mr. Chowning did not re-compute the section to eliminate this problem. He rather learned to accept it "as one does a birth mark or beauty mark on one's skin . . . noticeable but of no substantive consequence" (Chowning 2005c). This comment also makes clear that both IRCAM and CCRMA (*4-ch*) versions contained the discontinuity.

What Mr. Chowning says about the truncation is that he cannot "remember any conversation with Johannes about that, but that the truncation happens just before the 'click' makes me suspect that he/we decided to truncate before" (Chowning 2005c). Nevertheless, the truncated part lasts from 6'15" to 6'57"—that is, 43 sec. This is not actually the same durations Chowning declares in the Excel file (Figure 10 and Table 3), which lists a truncation of about 2 min (325 – 206 = 119 sec). The Excel file could be considered a hypothetical reconstruction by Mr. Chowning rather than a philological reconstruction of the process. (This is valid also for the image used in Mr. Bossis' article.)

The "faulty," imperfect, and therefore fascinating four-channel version is the version Mr. Chowning now uses to play during the concerts. (I have personally verified this fact during a concert given at the Bourges Festival of Electroacoustic Music during June 2005.) Thus, we should emphasize that the *Stria* version that audiences know from live performance with spatialization has a discontinuity in the D/A conversion at 6'29".

WER also contains an extended fifth T754G section that is completely truncated in *4-ch.* The fact that the Wergo CD was made from the original sound files that had been transferred from the mass storage disk make me suspect that the original T754G had probably been considered too long by the composer for the CCRMA version and, maybe, for the IRCAM version, but that the truncation the CD was neglected, for reasons that I leave to further research.

Another discrepancy emerges in the overlapping of some sections. What Johannes Goebel says is that after listening to *Stria* many times before putting the CD together, he saw that there was never a pause in it anywhere (Goebel 2005). *WER* does not contain silence, but the *4-ch* version almost diminishes to silence between the first section `T0` and the second, `T286`. In the Wergo version, the two sections overlap for 3 sec. (Table 3, left, shows the time overlapping.) The CCRMA version (*4-ch*) fades to a very feeble sound; during the first listening, I thought there was a silence of 2 sec. As Mr. Chowning says, "This difference was not preserved in the Wergo version. This was an important break or caesura in my conception of the piece" (Chowning 2005c).

Another important—this time functional—difference between the CCRMA version (*4-ch*) and the Wergo (*WER*) version relates to the dynamic range. John Chowning informed me:

> When I saw your two-channel/four-channel signal comparison [Figure 14], I remembered an important discussion that Johannes and I had having to do with dynamic range. The loudest parts of the two versions are at about the same level, but the soft parts of the Wergo CD are much louder. Johannes felt that if the beginning was as soft as I had composed it, the listener would turn up the volume, thinking it was under-recorded and reduce it later at the loud part. He felt that a compromise was better than distorted or interrupted listening (Chowning 2005).

That was a practical adjustment necessary for domestic listening. After this discussion, Mr. Chowning remembers he only had time

> to listen to and agree on the beginning and the loud section. Johannes, also extremely busy, returned to Germany and I did not realize that the Wergo version and the tape that I was playing at concerts are not the same. The Wergo CD of *Stria* is just under 17', while the *4-ch* tape that I assembled and mixed with the sectional overlaps at IRCAM before and again right after the first performance, is 15'46" (Chowning 2005c).

Ultimate Description of the Assembling Process

It is now possible to trace a first attempt to reconstruct the process of *Stria*'s assembling. The analysis of different sources would, in many cases, have been insufficient for my purposes. It has been helped by oral communications, which in some cases, still need further research. The actual investigation leads me to outline the stages in the history of the mixing, listed in Table 4. I have submitted my conclusions to John Chowning, who has personally added some other steps he remembered. These new stages, which also need to be further validated, are within brackets. (Step 3 is particularly interesting, because it cannot be verified by any of the sources.)

These results show the history of the synthesis of sections and the various stages of assembling. Four stages emerge: (1) a complex compositional process of sections 1–5; (2) the IRCAM conjectural version before the premiere (future research hopes to find the tape of this very first IRCAM version); (3) the CCRMA version made the day following the premiere; and (4) the Wergo recording.

Further investigation could bring to light other sources or witnesses that could add other details and confirm or contradict my conclusions. I wish to underline that the philological investigation has stressed the important role of the collaboration between the composer/producer/technician Johannes Goebel and John Chowning. A collaboration causing an interesting double identity of *Stria* that has never perturbed the fortune of the piece, its beauty and the listeners' appreciation.

Criticism based on Table 1 and what emerges from Table 4 emphasizes that the only real autograph among these sources is what I have called *JCdig*. An autograph is a "manuscript" by the author. These are printed sources from the original digital data used for the synthesis or other handwritten documents. Deleted sections (Table 4, step 1, `T166`, longer and shorter sections) are the so-called sketches. Some of them unfortunately have been lost but their traces remain in the *JCdig* source. The Wergo version appears to be an authorized edition of the piece, realized under the control of Mr. Chowning. But the fact that the penultimate section shows a difference in timing could make

Table 4. History of the Various Stages of Assembling

Phase	*Date*	*Number of sections*	*Comments*
1	1977	?	First experiments included T0, a shorter section END, T163, T377, T466A, inharm (Figure 11), and a shorter section than the others, with the procedure event2 in a less-developed state (the composer later renamed it END.MEM; *JCdig*)
2	1977	4	Sections T166–T286 (325")–T610—T754G (long version, 234")
3	1977	5	The composer creates T466 (144") and decides to truncate T286 (the first truncation is faded out, but Mr. Chowning keeps the data: 252" instead of 325")
4	1977	6 sections	Alternative sections, according to Mr. Mountain's sketches (Figure 13): T0 (166")–T166 (268")–T466 (144")–T610 (144")–T754 (version 234")–END (145", without T286) (Mountain 1980, note.07) Duration: absolute duration (without overlapping) 1101", i.e., 18'21" (perhaps this corresponds to Dodge and Jerse's scheme); Mountain 1980 (note.03) indicates 16'27" (987"); future research is needed
5	1977	6 sections	Nominal version: hypothetical reconstruction by John Chowning adapted to the *WER* version, before the philological investigation (Figure 10, June 2004) T0 (166")–T286 (252" version, with discontinuity)–T466 (144")–T610 (144")–T754G (234")–END (145") Duration (with overlapping): 1019", i.e., 16'59"
6	1977	7 sections IRCAM version	IRCAM version, first performance (Figure 12) Duration in Figure 12: 987", i.e., 16'27" T0 (166")–T163/6 (268")–T286 (252" version with discontinuity)–T466 (144")–T610 (144")–T754F/G (234" or 111")–END (145") Absolute duration without overlapping: 1230" (20'30" if T754G is 111") or 1353" (22'33" if T754G is 234")
7	1977–1978	6 sections CCRMA version	Following the first performance, Mr. Chowning manually cut the whole section tape of T166 (static section). Sections T0 (166")–T286 (252" version with discontinuity)–T466 (144")–T610 (144")–T754G (short version, 111")–END (145") Duration : 15'46"
8	1988	6 sections Wergo version	T286 third truncation (206"): Mr. Chowning truncated the discontinuity T754G (long version, 234") Compromise in dynamic range Duration: 16'57"

one deduce that it is a version with the so-called editorial integrations, which has become authorized in the course of the years. Variant criticism has identified two alternative variants. Variants exist when two or more versions co-exist, and their author does not choose between them.

It is also meaningful to show the last Excel file (see Figure 16) John Chowning sent to me, presenting what he recollects after my and his research work. The version for the first performance still remains the most problematic version, because its timing conflict with my reconstructions and remain obscure. Further investigation could adjoin new information concerning the various stages of assembling and an additional aspect not considered in my research, which is the control and the accuracy of

Figure 16. A comparison of the IRCAM, Wergo, and CCRMA versions made by John Chowning (2006).

Figure 17. Excel data with durations and overlapping of the sections, as reconstructed by John Chowning (2007). Note: In this figure, John Chowning reduced the durations of sections T0, T286, T754, *and* END, *according to their begin time of 1 sec rather than 0 sec. (The offset was to allow editing out a click produced on the tape by the DACs [Chowning 2007].) For the purpose of my research, I decided to consider only the pure data shown in* JCdig.

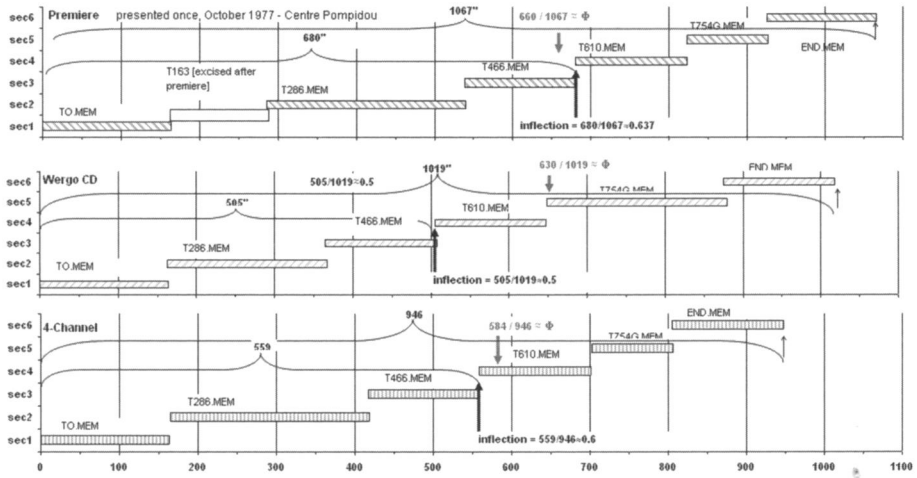


Figure 16

		sec dlta	latest beg			latest end					SecBegTime
	T0.MEM	6,3	158,7	2	38,7	165	2	45			1
***truno	~~T286.MEM~~	~~2,6~~	~~321,4~~	~~5~~	~~21,4~~	~~324~~	~~5~~	~~24~~			1
actualCD	T286.MEM	9	196	3	16	205	3	25			1
	T466.MEM	3	141	2	21	144	2	24			0
	T610.MEM	7	137	2	17	144	2	24			0
	T745g.ME	29	204	3	24	233	3	53			1
	END.MEM	31	113	1	53	144	2	24			1
Fibonacci numbe		*1*	*1*	*2*	*3*	*5*	*8*	*13*			*21*
		34	*55*	*89*	*144*	*233*	*377*	*610*			*987*
premiere	121		**beg time**	duration	**end time**	**overlap**	**beg m s**		**dur m s**		**end m s**
	t0	sec1	0	165	165		0		2	45	2 45
	t286	sec2	286	255	541	-121	4	46	4	15	9 1
	t466	sec3	538	142	680	3	8	58	2	22	11 20
	t610	sec4	680	144	824	0	11	20	2	24	13 44
	t745g	sec5	823	105	928	1	13	43	1	45	15 28
	end	**sec6**	**926**	**141**	**1067**	**2**	**15**	**26**	2	21	**17 47**
VergoCD			**beg time**	duration	**end time**	**overlap**	**beg m s**		**dur m s**		**end m s**
	t0	sec1	0	165	165		0		2	45	2 45
	t286	sec2	183	205	368	2	2	43	3	25	6 8
	t466	sec3	365	144	509	3	6	5	2	24	8 29
	t610	sec4	505	144	649	4	8	25	2	24	10 49
	t745g	sec5	648	233	881	1	10	48	3	53	14 41
	end	sec6	875	144	1019	6	14	35	2	24	16 59
Tape 4-ch			**beg time**	**duration**	**end time**	**overlap**	**beg m s**		**dur m s**		**end m s**
	t0	sec1	0	165	165		0		2	45	2 45
	t286	sec2	165	255	420	0	2	45	4	15	7 0
	t466	sec3	417	142	559	3	6	57	2	22	9 19
	t610	sec4	559	144	703	0	9	19	2	24	11 43
	t745g	sec5	702	105	807	1	11	42	1	45	13 27
	end	sec6	805	144	949	2	13	25	2	24	15 49

Figure 17

the Fibonacci series applied to the various stages of assembling.

The analysis by synthesis and re-synthesis of the piece is a fundamental counterpart to my conclusions. Olivier Baudouin and Kevin Dahan have faced, among other aspects, the problem of durations and exact timings of the overlapping sections (see Baudouin 2007 and Dahan 2007 in this issue), as shown in Figure 17.

It must be emphasized that their works, super-

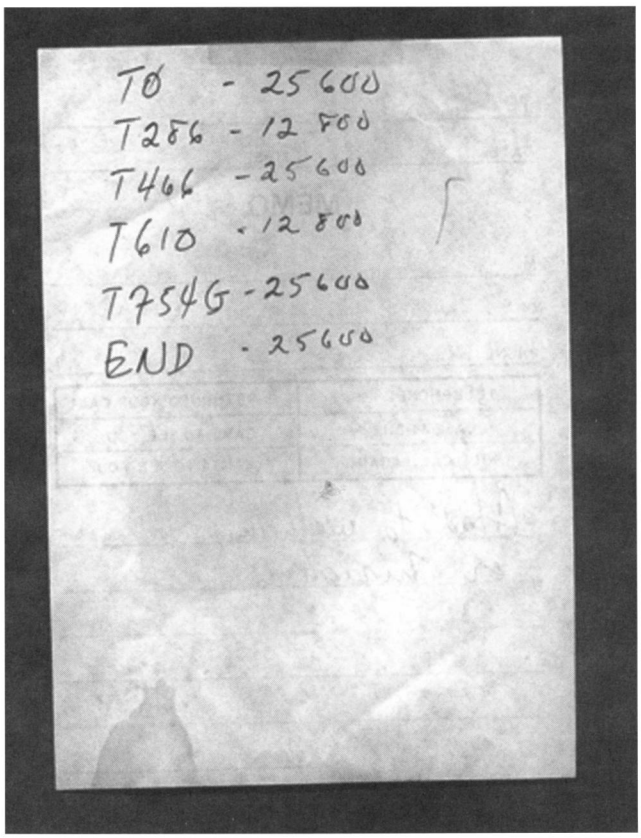


Figure 18. Sampling rates of the sections (Chowning 1977(!)a).

vised by the composer, have led to a reconstruction of the piece that matches the CCRMA four-channel version (Chowning 2007). That allows me to state that the CCRMA version corresponds to the best *Stria* version. The re-synthesis corresponds partly to the authorial level (Caraci Vela 2005, p. 221), namely, the moment in which authors establish their own true versions. This is the revision by the author himself, where he fixes a new and definitive version of his work. On the other hand, it is not entirely a revision of his own, since the synthesis is made by Mr. Baudouin and Mr. Dahan. This fact could involve other consequences, musicologically speaking, related to the interpretation, the identity of music and, maybe, possible "new" versions.

Another important and problematic aspect Mr. Baudouin and Mr. Dahan have encountered is the reverberation. One last source Mr. Chowning provided was Figure 18 (Chowning 2007). To complete the list of sources concerning the piece, I think it is worth presenting it, together with Mr. Chowning's recollection:

> Trying to remember how I modulated using `ZDELAY`, I realized something important. In the collection of notes that I have, there is this one [Figure 18] where I recorded the sampling rates that I used for each of the sections. The expense (in time) of these computations was so great that I economized. However, I am sure that I did not change the delay lengths (in samples) accordingly. So, it is an artifact; the reverberation time in `T286` and `T610` is twice as long as in the other sections (Chowning 2007)!

Following Mr. Baudouin's and Mr. Dahan's process of re-synthesis, it has been even clearer that the process of composition, even for one computer-music piece that is an intermediate point between parameter by parameter composition and automatic composition, pursues complex mechanisms where the machine control and determinism charmingly meets the human imprecision in the process of artistic creation. That is why I would like to conclude quoting John Chowning himself: "[T]here are times that the composer, even in his most rigorous mode (especially in those days when forced late nights, long computations, fatigue, and performance deadlines were not very compatible), is led by his ear to accept what has been done, as an *objet trouvé*" (Chowning 2007).

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