DEMETRIO STRATOS RETHINKS VOCAL TECHNIQUES: A HISTORICAL INVESTIGATION AT ISTC IN PADOVA

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ABSTRACT

Demetrio Stratos (1945-1979) was a singer known for his creative use of vocal techniques such as diplophony, bitonality and diphony (overtone singing). His need to know the scientific explanation for such vocal behaviors, drove him to visit the ISTC in Padova (Institute of Cognitive Sciences and Technologies) in the late Seventies. ISTC technical resources and the collaboration with Franco Ferrero and Lucio Croatto (phonetics and phoniatric experts), allowed him to analyze his own phono-articulatory system and the effects he was able to produce.

This paper presents the results of a broad historical survey of Stratos' research at the ISTC. The historic investigation is made possible by textual criticism and interpretation based on different sources, digital and audio sources, sketches, various bibliographical references (published or unpublished) and oral communications.

Sonograms of Stratos' exercises (made at the time and recently redone) show that various abilities existed side by side in the same performer, which is rare to find. This marks his uniqueness in the avant-gard and popular music scene of the time.

The ultimate aim of this study was to produce a digital archive for the preservation and conservation of the sources related to this period.

1. INTRODUCTION

Efstratios Demetriou (April 22, 1945 – June 13, 1979), better known as Demetrio Stratos, was a multi-instrumentalist, music researcher and singer. He is known for his activity with the Italian progressive rock group Area, as well as for his collaborations with other artists and his solo activity.

His interests in ethnomusicology and extra-European traditions, the complete mastery of a wide range of vocal techniques and the awareness of the spoken language constraints, were his background. That induced him to free the voice from the linguistic superstructures and to explore the underlying sonic substance. Among the most impressive results of his research on what he called the instrument-voice [1], a series of unbelievable performances must be mentioned, mainly in the whistle register, producing two or three inharmonic partials at the same time, in a frequency region that could reach the 8,000 Hz.

During the late Seventies, Stratos visited several times the ISTC of CNR (Consiglio Nazionale delle Ricerche) in Padova (http://www.pd.istc.cnr.it/). Here, he worked with the physicist Franco Ferrero, who was an expert in phonetics, and with Lucio Croatto, phoniatric expert, to explore this vocal effects by the means of ISTC technical resources: a spectrograph of the VoiceIdentification and an electroglottograph (or EGG, or laryngograph) Elettro-Glottograph EG 830 by the F-J Electronics [9].

Unfortunately, Stratos' premature death at age 34 put an end to his research activity, which would have provided other results and assertions to his original view and definitely future pedagogical and scientific outcomes.

Why, thirty years after his death, the myth of Demetrio Stratos' voice is still alive and growing? His unusual extension of vocal techniques, the musical use of his vocal features and his penchant for scientific research, show the emergence of a figure in the musical scene who struggles against established vocal techniques and monody, but also against the established music industry.

What was Stratos looking for from phonetics, physicists, and phoniatric experts? In what way did he try to study his ability to obtain such complicated techniques? This paper is an attempt to reply to this double question.

The investigation starts from two premises. The first one is the necessity to study the Stratos' scientific experience through the sources, an aspect which has not yet been considered by literature. Literature normally has a target audience from the rock ambience. Stratos should be considered more broadly for his scientific contribution. His Paduan period is significant for this reason. It is a particular case where creativity rethinks science, as happened worldwide in the musical and scientific research centers (San Diego, Stanford Universities, Ircam, CSC in Padova, etc.). The Seventies drove musicians and scientists to collaborate in order to understand how voice and instruments physically worked (think e.g. the spectral analysis and physical models research, etc.). In this case, the performer himself decides to study his own voice and be more acquainted with his own capabilities.

The second premise emphasizes the problem of music conservation and preservation. The ISTC shares the same problem musical archives or musical institutions have. Oblivion or inaccurate preservation exist because of scientists and musicians continued acquisition of knowledge and the urge of experimentation, that brought to postpone, and often to forget, the organization and preservation of their musical materials [2, 3]. Together with the reconstruction of Stratos' experience, this research has been based on the philological method, in which the researcher follows different steps in his investigation. First of all the philologist aims to the complete *recension* and description of extant sources (even oral witnesses). Then he proceeds listing all different sources and name them with abbreviations derived from their content or origin. XX century music is characterized by heterogeneous sources (audio and video sources, sketches, digital sources, spectrograms and/or digital scores or description, oral witnesses) therefore he must consider all of them. The accurate description of the sources is the third moment of the investigation [4].

Section 2 gives an overview of the historical experience. Section 3 describes Ferrero and Stratos' work during the recording and the analysis of the vocal effects. Section 4 describes sources, methodological problems and the organization of the new archive with Stratos-related materials at the ISTC [5].

2. STRATOS AT THE ISTC (1976-1978)

This section tells the story of Stratos' presence at the ISTC, as derived from the sources mentioned in chapter 4.2.

2.1A necessity

Many are the reasons why Stratos had found the necessity to analyze his own voice compelling. First of all, as it is stressed by all Area members, Stratos' background was a melting pot of Greek, Egyptian and Balcanic musical traditions. Another field which certainly caused this interest were infant and newborn voices. Daniela Ronconi, Stratos' wife, told that Stratos was fascinated by his daughter Anastasia's voice, especially during the lallation phase;[1] he kept asking himself the reason why people lose this interesting capability while they grow up [6].

Another fact happened in 1974, when Stratos performed the John Cage piece *Sixty-two Mesostics Re Merce Cunningham* (1971) for voice unaccompanied using a microphone, a score that demands the performer a great independence and liberation. The occasion to meet Tran Quang Hai, a renowned interpreter of Eastern musical tradition and harmonic chant, was also important and allowed Stratos to learn this way of singing and its philosophical implication.

Finally, Nicola Bernardini had a relevant part in Stratos' experience. Bernardini (at the time a member of Prima Materia) met Demetrio Stratos and exchanged discussions. They used to perform overtone singing competitions («we travelled together a lot at the time, and practicing the overtone singing was the best pastimes!» [17]).

2.2At the ISTC

The musical experimentation was not enough for Demetrio Stratos. He needed to give a scientific explanation to the phono-articulatory phenomena. This is why he firstly asked Pino Sambataro, his reliable otorhinolaryngologist in Milan to study his voice. But because of his inability to understand how Stratos' voice worked, this doctor decided to contact a colleague in Padova, Maurizio Accordi, who was in his opinion a specialist in this field. Accordi and Lucio Croatto, director of the ISTC (at the time Centro per le Ricerche di Fonetica) examined Stratos' phono-articulatory system accurately, and found nothing unusual. No special instrumentation was used, but only a laryngeal little mirror, for the videolaringostroboscopy did not exist yet.

Then they thought to examine Stratos' voice also from an acoustical point of view, and take him to the ISTC [6]. This happened during Fall 1976, which is also confirmed by [5] and the researcher and physicist Kyriaki Vagges, who worked at the time with Ferrero at the ISTC, and is the sole witness alive of that meeting [8].

During their meetings, Ferrero and Stratos recorded several improvisations, which were analyzed to observe their spectral content (several papers were published under the names of Accordi, Croatto and Ferrero).

Unfortunately, it is difficult to date those meetings, and yet material sources (audio sonograms and paper sources) do not give any help. Nonetheless it is certain that Stratos went to the ISTC ISTC during the years 1976, 1977 and 1978 (daa-SSN, daa-D,[2] and [12]) and in 1999 Ferrero declared to Janete El Haouli that he worked with Stratos at the ISTC for 4 or 5 times [1: 129].

Audio sources and sonograms demonstrate that most of the vocal material was recorded at the ISTC. Only a small number of audio recordings were made at Stratos' home [6]. Since evidently no electroglottograph tracks exist of those materials, it is easy to establish which vocal effects were recorded at ISTC under monitored conditions.

2.3Recording Demetrio Stratos

Speech and glottic sources were recorded by Ferrero team in the ISTC silent room, respectively on a Revox A77 tape recorder, and an Electro-Glottograph EG 830 by F-J Electronics [8]. The equipment also included an oscilloscope for the real time visualization and the signal analysis [8].

The vocal and glottal signals were recorded on two separate synchronous tracks. The speech signal was captured from a microphone at 10 cm from the mouth. The glottic source was acquired by means of two electrodes, attached to both side of the neck, in correspondence of the larynx. This allowed to pick up the rough signal of the vocal cords, not filtered by the resonances of the vocal tract. The absence of articulatory effects takes away all

[1] The infant baby's gibberish (from Latin *lallāre*: to sing lullaby, a verb containing the concept of producing alliterative sounds). In phonetics it means more generally a defect of speech (replacement of L for R).

[2] The sources are listed in chapter 4.2.

intelligibility and all human characteristics from the sound, and makes it like a buzzing of a reed instrument.

The subsequent analyses were made on a massive Voiceidentification Spectrograph 700 (same machine used in forensic application) by Franca Zecchin, who did the very first study of those materials [9]. The maximum frequency band the machine could capture was 8 KHz, which explains why Ferrero-Zecchin analysis established that Stratos could perform some extraordinary bitonality effects reaching 7000 Hz [12]. However, today analysis (made in 2002) has allowed to determine that Stratos' maximum was much higher, of about 8000 Hz (Fig. 3).

3. VOCAL EXERCISES AND ANALYSIS

3.1Stratos' original vocal technique

Stratos' ability allowed him to produce diplophony, bitonality and diphony (overtone singing) [10].[3] Diplophony is the ability to make two sounds at the same time. Vocal cords vibrate asymmetrically, and produce a waveform period with normal amplitude followed by a feebler one. One cannot always perceive two separate sounds: a normal period followed by an anomalous period means that the perceived frequency is one octave lower (for psycoacoustic reasons it is sometimes difficult to distinguish). If two normal periods are followed by one abnormal, the pitch of the perceived sound results an octave and a fifth lower [10]. What is heard, consequently, is a 'dirty' and scratched voice, because two frequency components fall in the same critical band and because of the masking of the lower partials above the higher. If this phenomenon can be sometimes accidental in the pathological voices and sometimes also in singing, Stratos made it intentionally.

Bitonality is the unusual capability to produce two different sounds which are sometimes not in a harmonic relation. In normal conditions, the vocal folds produce a sound with harmonic spectral components, i.e. the frequencies of partials are multiple of a fundamental, or separated by the same frequency interval. Sometimes the contraction of false vocal cords provokes a second sound due to the low frequency modulation. Some other times, strong false vocal cords contractions trigger very high whistles. In the case of bitonality, the adduction of vocal cords is so strong that it generates two independent non-harmonic sounds, as it happens when you touch with a finger the string on a musical instrument and the original sound splits in two. In some of Stratos' effects, the EGG demonstrated the absence of the vocal cords vibration: in this case, the perceived pure high frequency whistles are due to the reduced dimension of pharyngeal resonators [10].

Overtone singing is the extraordinary way to split the harmonic partials of a vocal sound, normally fused in a single one, in two distinct sonic images: one in the usual vocal range of the singer, the other in an high or very high register; this pure and flute-like sound corresponds to one of the harmonic partials reinforced by the resonances or formants of the spectral envelope. In enhancing the harmonic partial, one can create real melodies. An overtone singer can 'play' these harmonic pitches in a scale which is a natural pentatonic scale (see Zarlino) [10].

3.2Analysis and Sonograms

Analyses of Stratos voice are mentioned in the following sources: dav-L, dc-VAL82, dc-RIV80, dc-RIV80/cp, dc-T/BATT, dc-T/COP, dc-CE/CNR, dc-SON, dc-T/ZECC (see Table 2).

Franca Zecchin's graduation thesis is the first study dedicated to Stratos' vocalizations. It is a very significant source because it was made during the period in which Stratos came at the ISTC [9, 11], and because it allows establishing the origin and reliability of the audio sources. In this way it is possible to verify that nearly all Stratos' vocal effects were recorded at ISTC in controlled conditions, and cannot be the result of a (fraudulent) mixing, filtering, etc. From the entire series, Ferrero's team selected a set of 22 vocalizations to be the most representatives.

The thesis reports that examples from n.1 to n.18 were recorded at the CNR during the fall 1976. Vocalizations nn. 19, 20, 21 were brought by Stratos in September 1977, pre-recorded on a tape. Vocalization n. 22 was recorded during the Fall 1976 [9]. All those examples were subjected to analysis, even if some of them (nn. 1-6 and 12, 15, 16) do not appear in Zecchin's thesis nor in the published article [9] (Zecchin also does not mention vocalizations nn. 7 e 11).

The electrographic track of vocalizations nn. 8-10, 13, 14, 17, 18 is completely flat because of the absence of the vocal folds vibration.

The thesis also includes a brief description of Stratos' phono-articulatory attitude during the vocalization, but not the way it was deduced. Unfortunately, after 30 years, Zecchin does not remember the methodology they adopted. She makes two assumptions: the described vocalization mechanism could be a deduction made *a posteriori*, through the study of the sonograms and the formant positions and movements. A more likely explanation could be that Ferrero discussed with Stratos about what he felt inside his phono-articulatory system, and compared this 'sensations' with the sonographic results [11].

Figure 1 shows the analysis of fragment n. 18, as it is shown in the article made in 1980 [12]. It begins with 2 whistles of 3700 Hz (and 2nd harmonic, small triangle) and 5000 Hz (empty triangle).

[3] Vocal analysis is one of Graziano Tisato's research topic, started during the Seventies. Soon after Stratos Paduan period, Tisato met Ferrero, and decided to determinate a precise terminology for the vocal effects. These were published in [14]. In 1989 Tisato realized the first model synthesis for the overtone singing [18].

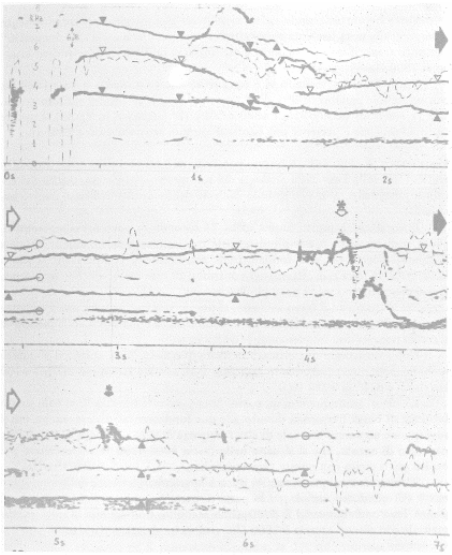

Figure 1. Vocalization n. 18 [12: 253].

In a graduation thesis made in 2005, Copiello showed new analyses of the 22 examples, which had been made by Tisato [16]. They considered sonograms, pitches and intensities contours [16]. The numeric representation shows unquestionable advantages and it solves those resolution and frequency limits of the Sonograph 700, thanks to the possibility to choose the proper frequency and time scale, and to obtain the parameter values straight from the data analysis. Table 1shows the comparison [16]. Fig. 2 shows the same vocalization of Fig. 1 in an arbitrary time scale. The Fig. 3 shows a sonogram with an example of tritonality.

VOCALIZE N° 18	1977 THESIS	-Phono articulatory attitude: the same as in nn. 8, 9 and 13. Spectrographic Recording -Cue: two non harmonic whistled notes, one at 3700 Hz + 2°, the other as pure sound beyond 5000 Hz. Their frequency is decreasing. -1st s: transition phase after which they continue as pure sound with non harmonic fluctuations. Whistled bitonal sound. -2nd - 3rd s: a whistle overlaps for three times with a fundamental frequency at 1660 Hz + 2nd and 3rd , with the result of a three-partite sound. -4th s: the main whistle with a lower frequency disappears. A flat changeable whistle overlaps the whistled note, stabilizing around 1500 Hz: bitonal sound, like “bird singing”. -5th s: pitch at 1500 Hz + 2nd and flat inflected whistle (like bird singing) between 4000 and 5000 Hz. Electroglottographic recording: flat during the whole length. (vocalize 18 was recorded in 1976 at CNR. The tape include the verbal vocalize but not the glottic vocalize)
	1980 STUDY	(annotations are made only if the analysis is different from the one made in 1977) Spectrographic Recording -During the whole vocalize there is a noise band around 1200 Hz Electroglottographic recording: Not quoted
	2005 STUDY	(annotations where different) Spectrographic Recording: -Whistled at ~3555 Hz (La7) and 2nd harmonic; and beyond 5500 Hz pure sound. -1,5 s: the lover whistle loses the 2nd harmonic. -2-3 s: whistle at ~1660 Hz (Sol6)

Table 1. Vocalize n. 18: comparison between [12: 253] and the new analyze with modern sonograms [16].

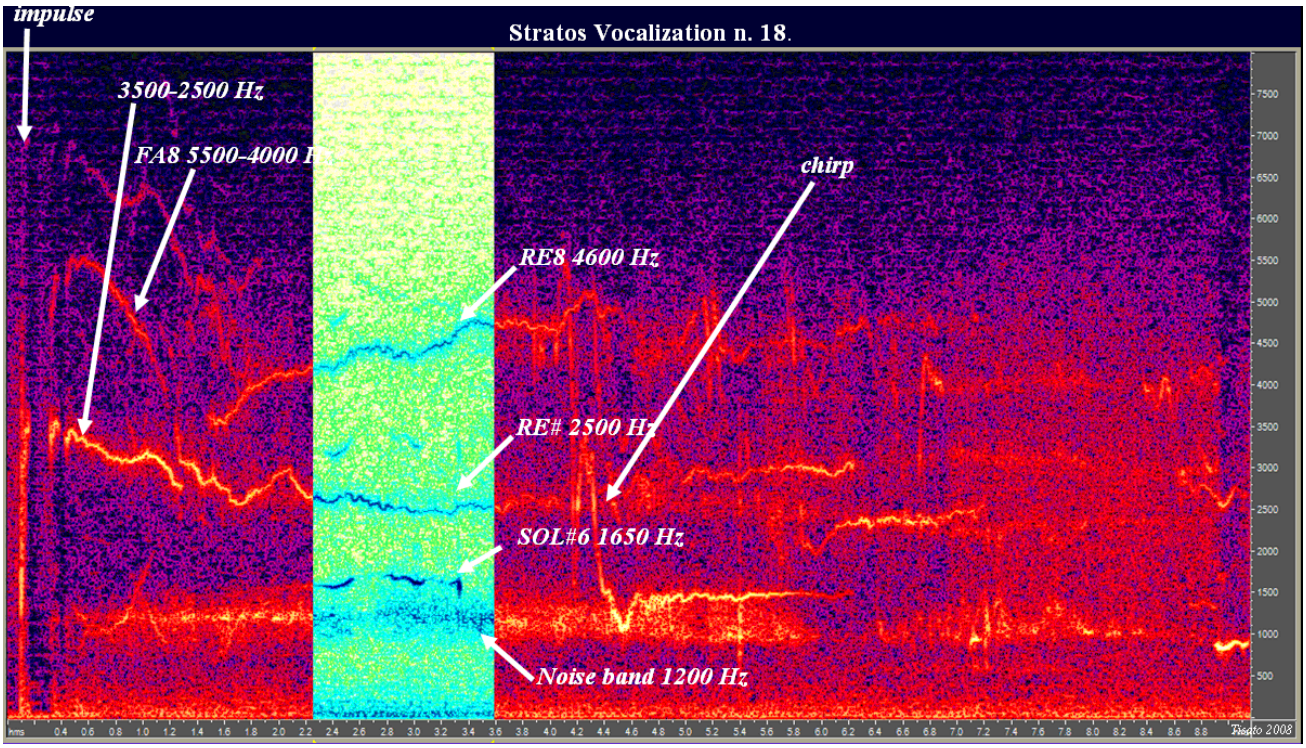

Figure 2. The vocalization starts with a guttural impulsive sound, then it proceeds until 2.2 s with two inharmonic whistles (bitonality case): the lower at 3500-2500 Hz presents a second harmonic, the higher slopes down from 5500 to about 4000 Hz. At this point until 3.3 s. a new inharmonic component appears at 1650 Hz to form the tritonality. Around 1000-1200 Hz a very narrow noise band can be heard.

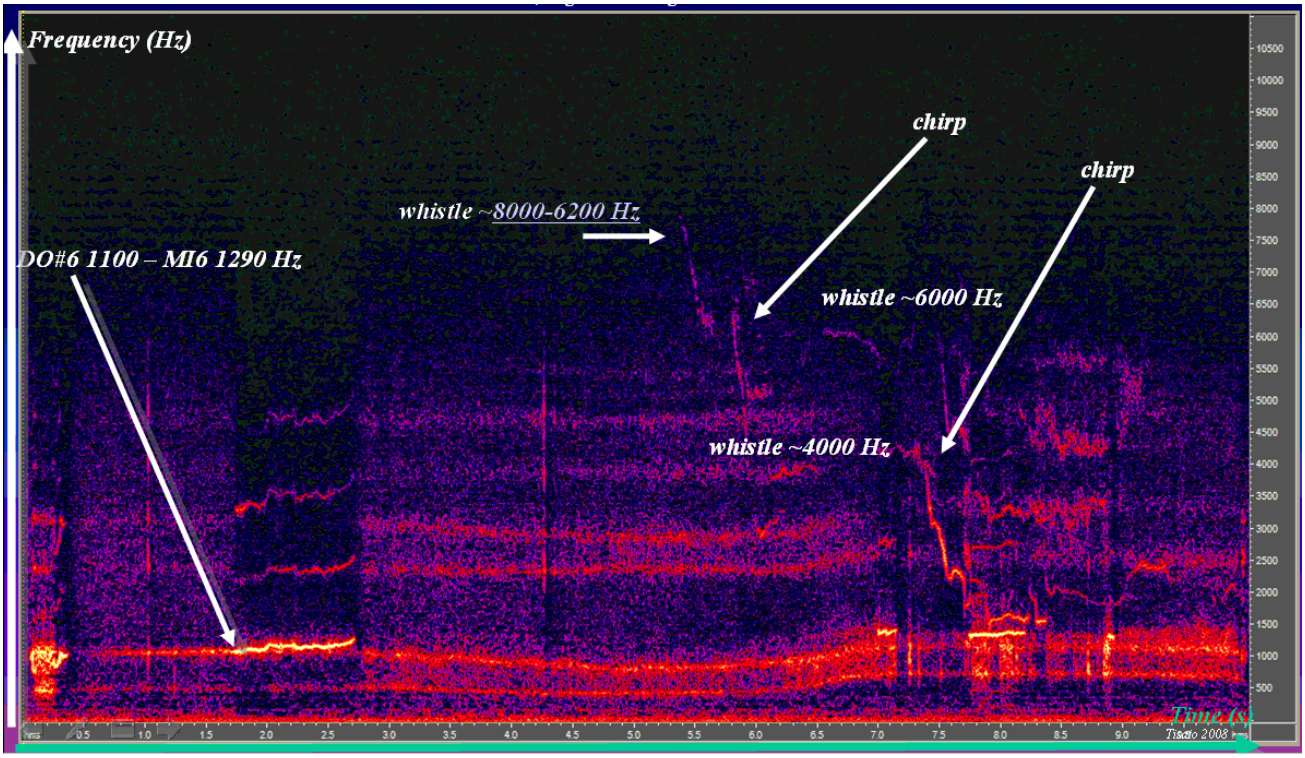

Figure 3. The vocalization starts with a breathy-vocalized sound of 300 ms, then 600 ms of an expiratory noise of low amplitude. At ~1.4 s, an high pitched cry with a set of 4 harmonics of 1 s can be heard, which raises from ~1100 (DO#6) to 1289 Hz (MI6-). Between 5-8 s, a chirp go down from ~7900 Hz to ~6200 Hz. Between 6-7 s a whistle appears at 4000 Hz and then at 6000 Hz. There is also a colored noise with 2 formants at 500 and 1000 Hz. At 7 s a chirp falling from ~4400 to 2250 Hz.

4. SOURCES

4.1New texts and supports in philology

During the past half-century music and musical research (in both popular music and art music) have been made involving new ways of producing and analyzing sounds. As a result, sources that document information of this activity are heterogeneous and very different from the traditional status of 'paper material' [13]. They are not necessarily a visible or symbolic trace and can indifferently be: 1) the audio and video source (analogue, CD, the mini disc, the memory of the computer); 2) printed, handwritten sources; 4) traditional scores; 5) different sketches; 6) articles; 7) oral witnesses (oral communications find justification in the contemporary context where collaboration is important); 8) visual representations such as sonograms [3, 4]. Stratos' experience is a good example of a XX century historical event that must be studied in detail– in terms of material and oral documentation. Chapter 4.2 shows the list of sources. Oral communications have been indispensable in reconstructing the historical facts and are included in [5].

4.2Sources at the ISTC and elsewhere

Table 2 lists all materials collected during this research project. General Cathegories of sources are: Analogue audio document (daa), Visual analogue document (dav), Paper document (dc), Audiovisual digital document (dda). For specific description, see [5].

SOURCE	Abbreviation
"*Cantare la Voce*" (long play disc)	daa-CV
"*Copia disco dimostrazione Titze*", (magnetic tape 1/8", SONY HF-ES60, compact cassette)	daa-CT
"*Demetrio*" (magnetic tape 1/8", BASF Chromdioxid 90, compact cassette)	daa-D
"*Lo strumento voce , demo Lecce 14/4/94*" (magnetic tape 1/8", SONY Metal-xr 100, compact cassette)	daa-SVL
"*Metrodora* " (long play disc)	daa-M
"*Napoli* " (magnetic tape 1/8" BASF Chromdioxid 60, compact cassette)	daa-N
"*Nastro cantanti 75/78* " (magnetic tape, BASF, plastic flange)	daa-NC75/78
"*Nastro pre-Tesi , copia nastro Tesi, Stratos vocalizzi riversati*" (magnetic tape 1/8", BASF Chromdioxid 60, compact cassette)	daa-NPT
"*Nastro Tesi su Demetrio Stratos*" (magnetic tape 1/8", BASF Cromdioxid 90, compact cassette)	daa-NTD
"*Spectrograph7 (Stratos)*" (magnetic tape, BASF Scotch, plastic flange)	daa-S7
"*Spectrograph 20* " (magnetic tape, BASF, aluminium flange)	daa-S20
"*Stratos Ferrara*" (magnetic tape 1/",BASF Chromdioxid 90, compact cassette)	daa-SF
"*Stratos Milano*" (magnetic tape 1/8", TDK, SF60, compact cassette)	daa-SM
"*Stratos suo nastro* " (magnetic tape 1/8", TDK KR C60, compact cassette)	daa-SSN
Slides (mixed), ISTC archive, Padua	dav-D
"*Lo strumento voce , demo Lecce 14/4/94*", transparencies, ISTC archive, Padua	dav-LSV
Transparencies, no date, ISTC archive, Padua (two parcels)	dav-L (two parcels)

SOURCE	Abbreviation
	dav-L1 (first parcel) dav-L2 (second parcel)
Accordi M., Croatto L., Ferrero F. E., "*Analisi spettrografica di alcuni vocalizzi di Demetrio Stratos*". In "*Il Valsalva, bollettino italiano di audiologia e foniatria, Vol. V – N. 1*", January - April 1982, pp. 2-8	dc-VAL82
Accordi M., Croatto L., Ferrero F. E., "*Descrizione elettroacustica di alcuni tipi di vocalizzo di Demetrio Stratos*". In "*Rivista Italiana di Acustica, Vol. IV – N. 3*" 1980, pp. 229-258	dc-RIV80
Accordi M., Croatto L., Ferrero F. E., "*Descrizione elettroacustica di alcuni tipi di vocalizzo di Demetrio Stratos*". In "*Rivista Italiana di Acustica, Vol. IV – N. 3*" 1980, pp. 229-258, copy of the original typewritten publication	dc-RIV80/cp
Accordi M., Ferrero F., Ricci Maccarini A., Tisato G., "*Il canto difonico, un esempio delle possibilità del tratto vocale*", comunicazione presentata al "*XVIth Congress of Union of the European Phoniatricians, Salsomaggiore, 10-14 Ottobre 1990*". In "*Quaderni del centro di studio per le ricerche di fonetica, vol. IX, 1990*", pp. 574-613	dc-CDIF
Baroni Vittore, "*Cometa Rossa: la Musica è un Gioco Rischioso*", pp. 31-33, no date	dc-COM
Battain Valeria, "*Un archivio di documenti sonori non convenzionale: il fondo Demetrio Stratos dell'ISTC (Istituto di Scienze e Tecnologie della Cognizione, ex Istituto di Fonetica e Dialettologia) del CNR di Padova*". Thesis of the Academic year 2006-2007, Università degli studi di Udine, Supervisor: Professor Sergio Canazza Targon	dc-T/BATT
"*Cantare la voce*", poster, congress programme and brochure, Monday 29th e Tuesday 30th May 1989, ISTC archive, Padua	dc-CV/L (poster) dc-CV/P (congress programme) dc-CV/O (brochure)
Copiello Laura "*Demetrio Stratos, una vocalità riscoperta*". Thesis of the Academic year 2004-2005, Università degli studi di Venezia, Supervisors: Professori Giovanni Morell, Graziano Tisato e Domenico Stanzial	dc-T/COP
Fariselli Loretta, Fariselli Patrizio, "*Demetrio Stratos – Area, dieci anni di musica ed impegno*", programme of the demonstration on the 4th of July at 9.00 pm in Piazza Mercato, Marghera, unpuplished work	dc-FAR/09
Ferrero E. Franco, "*Attività di studi e ricerca sulla voce cantata*", study presented at "*Seminario CIRM, 5 Febbraio 1997*", unpublished work	dc-CIRM
Ferrero E. Franco, "*Caratteristiche elettroacustiche di alcune singolari vocalizzazioni di Stratos Demetriou*", Centre for the study of phonetic researches (CNR) in Padua, unpublished work	dc-CE/CNR
Ferrero E. Franco, "*Elenco delle pubblicazioni*", 30 Settembre 1997, ISTC archive, Padua	dc-EP
Ferrero F., Ricci Maccarini A., Tisato G., "*I suoni multifonici nella voce umana*", article presented at "*XIX Convegno Nazionale 10-12 Aprile 1991, Napoli*", pp. 415-422	dc-SM
Ferrero Franco, "*Elementi di Fonetica*", publication n. 85 from the list of publications, pp. 1-43	dc-EF
Ferrero Franco (hypothesis of the autor based on the hand writing), "*Fonetografia e costo vocale*", study, without date, ISTC archive, Padua, unpublished work	dc-FON
Ferrero Franco, "*La fonetica strumentale in funzione della diagnostica foniatrica e della riabilitazione logopedica*", notepad bound by hand, handwriting by Ferrero, without date, ISTC archive, Padua	dc-FS/lib
Ferrero Franco, "*Lo strumento voce*", study, without date, ISTC archive, Padua	dc-SV
Ferrero Franco, three lists of thesis (supervisor F. Ferrero), ordered by location, Academic year and alphabetical order of the titles, without date, ISTC archive, Padua	dc-T/el
Tissue paper sheets, without date, ISTC archive, Padua	dc-FCV
Sheet of paper with the description of vocalizes 18 and 6 (copy of a page "*Caratteristiche elettroacustiche di alcune singolari vocalizzazioni di Stratos Demetriou*" attached to the first parcel of transparencies), without date, ISTC archive, Padua	dc-L1
Fortunato Roberto, "*Rinasce la ricercata etichetta Cramps*". In "*Il mattino*", Tuesday 11th July 1989, pp. 41	dc-R.CRAMPS/Mat
Gatti Roberto, "*In alto la voce*". In "*L'Espresso*", 4th of June 1989, pp. 135-136	dc-IAV/Esp
Kemp Alan, Linsdey Geoff, Verhoeven Jo, "*Practical Phonetics*", Edinburgh University Linguistics Department, pp. 1-8, without date	dc-PP
"*La musique religieuse du Thibet*", Bulletin du Groupe d'Acoustique Musicale, 58, Université Paris VI, 1972	dc-MR/Th
"*Lo strumento voce, demo Lecce 14/4/94*", sheets with notes	dc-SV/app
Transparencies, paper copy, without date, ISTC archive, Padua, (two parcels)	dc-Lc (two parcels) dc-L1 (first parcel) dc-L2 (second parcel)
Mangiarotti Marco, "*Stratos: la musica è gioia e rivoluzione*". In "*Il giorno*", Sunday 25th June 1989	dc-MGR/Gio
Mattarelli Luca, "*Demetrio Stratos, una nuova vocalità*". Thesis of the Academic year 1994-1995, Università degli studi di Bologna, Supervisor: Professor Gino Stefani	dc-T/Matt
"*Nastro cantanti 75/78*", cover with notes, without date, ISTC archive, Padua	dc-NC75/78
Ricci Maccarini Andrea, "*Il canto difonico*". Thesis of the Academic Year 1989-90, Università degli studi di Padova, Supervisor: Professor Maurizio Accordi, Co-Relatore: Dott. Franco Emilio Ferrero	dc-T/RIC
Receipt of payment to Franco Ferrero for the conference he held on the 29th of September in the auditorium San Rocco – Vocal Music Festival called "*Caratteristiche elettroacustiche di alcuni tipi di vocalizzo di Demetrio Stratos*"	dc-RIC
Sonagrams (mix), ISTC archive, Padua	DC-SON
"*Spectrograph 7 (Stratos)*", white cardboard with notes and writings, without date, ISTC archive, Padua	DC-SP7
"*Spectrograph 20*", sheet with notes, without date, ISTC archive, Padua	dc-SP20
"*Vocalizzi di Stratos (pre-tesi)*", sheet with notes, without date, ISTC archive, Padua	dc-VOC/pt
"*Vocalizzi Tesi*", sheet with notes, without date, ISTC archive, Padua	dc-VOC/t
Zecchin Franca, "*Studio elettroacustico di alcuni vocalizzi di Demetrio Stratos*". Thesis of the Academic Year 1977-1978, Università degli studi di Padova, Supervisor: Professor Franco Ferrero	dc-T/ZECC
"*Copia disco dimostrazione Titze*", conservative copy CIF0001 of the ISTC archive (DVD-data: 2+2 tracks, WAV, 96kHz-24bit)	DDA-1
"*Demetrio*", conservative copy CIF0002 of the ISTC archive (DVD-data: 2 tracks, WAV, 96kHz-24bit)	DDA-2
"*Nastro cantanti 75/78*", conservative copy CIF0008_CCIR of the ISTC archive (DVD-data: 2 tracks, WAV, 96Hz-24bit)	DDA-8/C
"*Nastro cantanti 75/78*", conservative copy CIF0008_NAB of the ISTC archive (DVD-dati: 2 tracks, WAV, 96Hz-24bit)	DDA-8/N
"*Nastro cantanti 75/78*", conservative copy CIF0008_V of the ISTC archive (DVD- data: 1 track, MOV)	DDA-8/V
"*Nastro tesi su Demetrio Stratos*", conservative copy CIF0006 of the ISTC archive (DVD- data: 2 tracks, WAV, 96kHz-24bit)	DDA-6
"*Spectrograph7 (Stratos)*", conservative copy CIF0007 of the ISTC archive (DVD- data: 1 track, WAV, 96kHz-24bit)	DDA-7
"*Spectrograph7 (Stratos)*", conservative copy CIF0007_V of the ISTC archive (DVD- data: 1 track, MOV)	dda-7/V
"*Spectrograph 20*", conservative copy CIF0009_CCIR of the ISTC archive (DVD- data: 2 tracks, WAV, 96kHz-24bit)	DDA-9/C
"*Spectrograph 20*", conservative copy CIF0009_NAB of the	DDA-9/N

SOURCE	Abbreviation
ISTC archive (DVD- data: 2 tracks, WAV, 96kHz-24bit)	
"*Spectrograph 20*", conservative copy CIF0009_V of the ISTC archive (DVD- data: 1 track, MOV)	DDA-9/V
"*Stratos Ferrara*", conservative copy CIF0004 of the ISTC archive (DVD- data: 2 tracks, WAV, 96kHz-24bit)	DDA-4
"*Stratos Milano*", conservative copy CIF0003 of the ISTC archive (DVD- data: 2 tracks, WAV, 96kHz-24bit)	DDA-3
"*Stratos suo nastro*", conservative copy CIF0005 of the ISTC archive (DVD- data: 2 tracks, WAV, 96kHz-24bit)	DDA-5

Table 2. Sources for the study of Demetrio Stratos at the ITSC.

Several additional sources are not listed here: these are articles, dissertations, projection papers, sleeves/sheets and annotations related to the audio material. The existence of documentations scattered over an extended period of time– from the Seventies up to now– tells not only the interest towards Stratos, it also ensure the importance of his musical research.

4.3Conservation and Preservation

This project ultimate aim has been to preserve the entire documentation from obsolescence and deterioration; that is why, following the typology of sources, a digital archive has been made, which is now available at the ISTC. The digital archive purpose is: 1) to preserve a specific order (folders – e.g. digitization of paper materials – are maintained in the same sequence of the original sources), so that the sources cannot get lost in different places; 2) to preserve the chronology of their creation; 3) to guarantee the accessibility to whoever is interested; 4) to avoid damages to the authentic sources that could be caused by an incorrect use.

The archive refines and benefits of a previous research. In 2007 Valeria Battain created digital conservative copies of the entire documentation related to Demetrio Stratos at the ISTC [15]. The storage in digital format included three magnetic open tape reels (daa-NC75/78, daa-S7, daa-S20) and six compact cassettes (daa-CT, daa-D, daa-NTD, daa-SF, daa-SM, daa-SSN). Battain's study provides a descriptive paper and picture for each original source; it also includes other papers with technical information related to the process. It was however incomplete.

The new digital archive is divided into two parts: the first one is labeled "ARCHIVIO *Demetrio Stratos*, ISTC (Istituto di Scienze e Tecnologie della Cognizione), CNR, Padova"; it relates to a selected space inside one of the shelves at the ISTC; it correspond to 'tangible' documents (e.g. thesis, tapes, compact-cassettes, DVD with recordings made by the eng. Sergio Canazza, etc.); the second part is an external HD USB with the whole sources that have been digitized during this work. For the moment, the archive can be accessed only locally through the computers of the Institute (ISTC). The structure of the archive reflects the choice made in organizing the whole sources. It simply systematizes them in 4 macro-categories: analogue audio document (daa), visual analogue document (dav), paper document (dc), audiovisual digital document (dda). Each folder is a container for the digitalized documents. These are: 14 'analogue' audio documents, 14 audiovisual documents (digital), 4 visual documents ('analogue'), 40 paper documents. The documents are identifiable through the abbreviated text extension given during this research, instead of verbose and long names (see Table 2).

5. CONCLUSIONS

The reconstruction of Stratos' experience in Padova has been made possible by the collection, the description, the analysis and the comparison of sources. Yet, this study is needless to say the first step toward investigating Stratos' contribute to XX century vocal research. Just as an example, Stratos' position in the avant-garde vocal research is almost completely unknown, but many aspects of his life are critical. Area member Paolo Tofani recalls the precise moment when Stratos realized the novelty of the overtone singing [19]. It was in 1976/77, when a journalist brought to the group an audiocassette with sounds sung by Mongolians: Demetrio tried and tried until he finally succeeded, because he had been influenced by John Cage; they also went to meet Cathy Berberian repeatedly and took lessons from Tran Quang Hai [19]. Also, his friendship with Nicola Bernardini, member of Prima Materia Group, is crucial. And needless to say, the milieu and historical period in which Stratos' research took place are again crucial: the Seventies, when the youth movement reached Italy and the children of the second world war began their protest against the established culture and lifestyle. It is easy to state that this social rebellion reflects in the complete nonconformity and subversion of Stratos' technique, an aspect that affected Stratos' position in the musical industry, since his voice did not respect standardized vocal production, did not consider language's rules and, on the contrary, tried to get loose from the detention of the communicative act. Future studies need to take into account all aspects of this issue.

The investigation of Stratos' vocal effects may develop in two directions. The first one is related to the systematic investigation of the complete series of Stratos' vocalizes, which had not been analyzed so far (as said in 3.4). The second one could help in deducing Stratos' phonatory attitude: Voice Quality (VQ) methodologies and glottal source modelization techniques should be applied to the existing glottal tracks. In addition to the traditional parameters (Shimmer, i.e. the amplitude perturbations of the wave form; Jitter, i.e. the pitch perturbations; the Waveform Matching Coefficient, i.e. the cross-correlation between near periods; the Harmonics-to-Noise Ratio, i.e. the energy ratio between the harmonic partials and the noise components; etc.), it is in fact possible to extract more meaningful information: for example, the Glottal to Noise Excitation Ratio (GNE), which is used to discriminate among normal and pathological voices [20]. The available glottic tracks could give precious information about the glottal flow, in term of Open Quotient Oq = Te / T0, i.e. the ratio between the maximum excitation instant Te and the sound period T0, and the Return phase quotient Qa, the ratio between the return phase (in which the glottal flow reaches zero) and the closed phase of the vocal folds. The Return phase quotient proved to be the

most effective index of VQ, for it determines the sound Spectral tilt, i.e. the slope of the frequency envelope [21].

Another development is the one mentioned before. A web page of the archive would also be desirable (possibly at: www.pd.istc.cnr.it/Stratos), with the audio vocal material and the PDF documents (of course in agreement with the authors). Accessing the stock of documents via metadata would be imperative. The web access would guarantee a more large accessibility to the sources; this also should adhere to Stratos' personal interest in the study and dissemination of his own personal research.

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