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# Listening Training for Language Learners: The Tomatis Approach to Second Language Acquisition

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## Introduction

For more than 45 years, Alfred A. Tomatis, a French otolaryngologist, now in retirement, worked to elaborate and refine a theory of language acquisition and communication. This theory, described by Tomatis in numerous publications, resulted in a method of sound stimulation, or sound perception training, designed to enhance many aspects of language learning, including second or foreign language acquisition. Years of clinical experience led Tomatis to conclude that the ear plays a primordial role in both first and second language acquisition. In this respect his work agrees with that of a number of scholars in this country who have sought, over the past 20 or so years, either to create and propagate a teaching approach based on listening or to identify learner variables that may hinder the acquisition of second or foreign languages.

The 1970s and 1980s in the United States saw the emergence of what have come to be known as comprehension approaches to second and foreign language acquisition. These approaches, using first language acquisition as a model, focus on listening as the means of acquiring a second language "naturally," progressing from a period of silent listening to speech emergence to normal communicative language use. Terrell's Natural Approach (1977, 1982) and Asher's Total Physical Response (1974, 1986) are no doubt the best known of the comprehension approaches. The theory underlying these approaches is discussed in Krashen's *Principles and Practice in Second Language Acquisition* (1982), while articles included in *The Comprehension Approach to Foreign Language Instruction* (Winitz, 1981) present various points of view and describe program models.

The widespread reinstatement of foreign language requirements in the 1980s and 1990s spurred interest in the identification of learner variables that might be expected to affect language learning. In a series of articles beginning in 1991 and continuing throughout the decade, Sparks, Ganschow, and their associates have focused on underachievement in foreign language study. According to these researchers, a deficit in phonetic coding in the first language is primarily responsible for lack of success in foreign language learning on the part of students who do well in other school subjects.<sup>1</sup> The Sparks-Ganschow articles, which have been published in journals destined for foreign language professionals as well as in journals dealing specifically with learning disabilities, have set off a veritable

firestorm of controversy<sup>2</sup> since they may be seen to support the argument that there is a specific foreign language learning disability.<sup>3</sup>

Within the context of the growing professional interest in listening as a key variable in second and foreign language acquisition, it seems appropriate to introduce Tomatis' theory of language acquisition and its application through listening training to foreign language teachers and researchers in this country. This article will, then, begin with a general overview of the theory and its application in the form of sound perception training. This overview will be followed by a report on European research that is supportive of sound perception training. In the final sections of the paper, I will describe my own experience with applications of the approach to foreign language teaching in private and public settings, both in France and in the United States.

### Overview of the Tomatis Approach to FL Acquisition

According to Tomatis, speech production<sup>4</sup> is founded upon accurate speech perception. This axiom has implications for foreign language learning in that foreign language learners may be confronted with sounds that they do not perceive correctly. It is Tomatis' belief that the normal human ear, which at the outset is capable of perceiving sounds present in any language, gradually selects out the speech sounds uncharacteristic of the native language.<sup>5</sup> This phenomenon would explain, at least in part, the difficulty of many adult learners in comprehending and reproducing the sounds of a foreign language, especially a language containing sounds markedly different from those of the native language. Tomatis further believes that by means of listening training, it is possible to enable the ear to perceive sounds that have previously been incorrectly perceived, or not perceived at all.

In the 1950s, Tomatis used phonograms made possible by panoramic speech analyzers to calculate "envelope curves" based on the characteristic mean frequency of sounds collected from groups of speakers representing various language groups. Using this information, he established what he termed "ethnograms" of several major languages. His ethnogram of European French, for example, shows a preferred frequency band between 1000 and 2000 Hz with a peak at 1500 Hz, whereas his analysis of the phonograms of speakers of British English revealed an auditory preference for sounds between 2000 and 12000 Hz (Tomatis, 1977/1991b, p. 73). The frequency bands are based not on the fundamental sounds of the language but rather on its characteristic overtones. Tomatis states in *The Conscious Ear* that "every ethnic ear can be defined by its spectrum of receptivity" (1991b, p. 71). Delattre's (1965) work on the vowel formants of various languages seems to suggest that he held a similar view.

Another important aspect of Tomatis' theory of language acquisition is the distinction he makes between hearing and listening. Hearing, for him, is a passive process in which sounds are merely received, whereas listening is active and involves volition. Gilmore (1989), in his "Overview of the Tomatis Method," used an analogy with the eye to illustrate the distinction between the two. Hearing, for

Tomatis, is analogous to seeing; in contrast, listening can be compared to looking, which involves attention and focusing. Given this basic difference, motivation, or the desire to listen, becomes a key element of the language acquisition process.

To summarize, Tomatis' theory of language acquisition assumes (a) that there is a close link between speech perception and speech production; (b) that the desire to listen is crucial to language acquisition; and (c) that the ear can be reeducated to perceive and analyze sounds that it may have eliminated through an auditory selection process. Like most specialists in listening, Tomatis believes that the right ear is best suited for the analysis of speech sounds; and this belief, along with the assumptions stated above, is reflected in his program of sound perception training, which is accomplished by means of the Electronic Ear.<sup>6</sup>

The Electronic Ear, a device designed by Tomatis and patented by him in 1963, consists of filters, amplifiers and a sophisticated gating mechanism that function together to enable users to perceive and reproduce accurately the sounds of a given language. A magnetic tape recording constitutes the source of the sounds, which may be either language or music. The sounds are transmitted from the Electronic Ear through specially designed Tomatis headsets, which look very much like ordinary earphones but differ from them in that each is equipped with a transmitter that sits on the skull, thus allowing the user to perceive sounds through bone as well as air conduction.<sup>7</sup>

At the Centre Tomatis in Paris, clients wishing to learn a foreign language are first given a diagnostic test known as the Tomatis Listening Test. This test, administered by trained testers using a machine known as the Tomatis Listening Test System, results in a graphic display of the client's auditory profile (sound perception through air conduction, sound perception through bone conduction, localization of sound in space, pitch analysis, and ear preference for language sounds). Analysis of this listening profile enables specialists to design an individualized listening program for each client. Specifically, the client's listening graph is compared to an ethnogram, which, as we have seen earlier, is a composite listening curve embodying the critical range of frequencies of the foreign language. Comparison with the sonic characteristics of the foreign language makes it possible to establish an appropriate program of auditory training for the learner.

The listening-training program is designed to enhance sound perception by boosting the frequencies which were poorly perceived during the Tomatis Listening Test, with high frequency sounds being emphasized through a process of filtering that diminishes the lower frequencies. Further, the two channels of the Electronic Ear provide what might be called a listening "workout" by alternately encouraging users to relax or focus their hearing. In the course of the training, the sound from the left earphone is gradually decreased, thus guiding the user to rely more on the right ear in processing language sounds. Learners proceed gradually from receptive listening sessions to so-called "active sessions," in which they produce or reproduce the sounds of the language. At this point, a microphone is added to the previously mentioned equipment, thus creating an auditory-vocal feedback loop.

## Research Studies in Europe

The approach to second or foreign language acquisition described above has been applied, evaluated, and refined at the Centre Tomatis in Paris since Tomatis' early experiments in the 1950s. Until the last decade, however, listening training at the Centre was individualized and took place in listening booths rather than in a classroom setting. For this reason, we must look elsewhere for formal research on the application of the Tomatis approach to foreign language learning in a context that resembles classroom instruction, as we understand it.

Two studies of the application of the Tomatis approach to foreign language instruction in situations that may be considered typical of school-based instruction have been conducted in Europe during the past 20 years, one at the secondary and another at the university level. An examination of these studies will illustrate how an essentially individualized program of listening training can be adapted to a group setting within the constraints of a school environment.

During the 1976-77 school year, three English teachers, who were also trained in psycholinguistics, investigated the use of Tomatis training in the acquisition of British English at the Athénée Royal pour garçons et jeunes filles, a lycée located in Comines, Belgium (Vanthuyne, Debruyne, and Schenkel, 1977). The researchers divided the 31 students who participated in the study into an experimental and a control group matched for gender, overall scholastic record, grades in French (their native language), and their results on the individually administered Tomatis Listening Test. The control group followed an audio-oral-visual program of English language instruction over the entire academic year while, until the Christmas recess, the experimental group followed a program that consisted of music and English language tapes processed by the Electronic Ear. In January the latter began the same audio-oral-visual language program that the control group had followed since the beginning of the school year.

Comparisons of selectivity (the ability to analyze sounds in relation to each other) and of spatialization (the ability to localize sounds in space) based on the results of administrations of the Tomatis Listening Test in September and in June favored the experimental group. For example, the composite spatialization errors of the experimental group declined from 18 to 3 over the year, whereas spatialization errors of the control group declined only from 22 to 21. Concerning selectivity, the results also favored the experimental group. In the experimental group, only two students had made no errors in sound analysis<sup>8</sup> in September; by June, however, that number had increased to nine. Four students in the control group made no errors in September; this number remained unchanged in June. Over the year, the total number of errors in selectivity declined from 27 to 13 in the experimental group and from 22 to 20 in the control group. In addition to the Tomatis Listening Test, the two groups were compared on separate measures of rhythm and pronunciation.<sup>9</sup> In both cases, the experimental group outperformed the control group. Although no statistical tests were applied, the raw scores reported by the researchers consistently favored the experimental group in sound analysis, localization of sound in space, rhythm, and pronunciation.<sup>10</sup>

In a more recent study, this one at the university level, Kaunzner (1997) and associates at six institutions<sup>11</sup> conducted a research project supported by the European Union over a period of three years between 1993 and 1995. The goals of the project were: (a) to test the efficiency of the SPT (sound perception training) method in terms of pronunciation improvement through acoustical stimulation and (b) to develop didactic pronunciation material for the target languages intended, namely German, Italian, Dutch, and Spanish.

In her discussion of the German study, Kaunzner (1997) reports highly positive results in favor of the SPT group on the Tomatis Listening Test and on a variety of tests of receptive (phoneme differentiation, sound discrimination, and word stress) and productive (reading aloud, repetition, and free expression) language. Based on a statistical analysis of the results of these tests, Kaunzner concludes that a student working with the SPT method would be able to achieve the desired pronunciation results in almost 50% less time than another student from the same class who did not receive such training. The significant and consistent advantage of the group trained in sound perception over the comparison groups in this study is all the more impressive because the sound perception training was done without intervention from a teacher, whereas the comparison groups were actually teacher directed.<sup>12</sup> Kaunzner speculates that sound perception training “may be of considerable help in a multilingual comprehension approach because the training actually ‘opens up’ the ear and the learner acquires greater sensitivity towards auditory input in general” (p. 9). While she expresses the opinion that the average foreign language learner at whatever stage of proficiency can profit from either systematic or occasional sound perception training, she identifies four groups of learners in particular who may be able to profit from an SPT approach: adult learn-advanced learners who seem to have reached a plateau, isolated learners who must learn a language autonomously, and young learners with special hearing difficulties.

### Tomatis Approach: A Personal Account

Although the Tomatis approach is familiar to many in Europe, it is hardly known in foreign language circles within the United States. This gap may be due, at least in part, to the fact that it requires special equipment as well as specialized training in administering the Tomatis Listening Test, interpreting the results of the test, and manipulating the controls of the Electronic Ear. A sabbatical leave from the University of South Carolina made it possible for me to be associated with the Centre Tomatis in Paris from July 5, 1994, through June 29, 1995, during a time I completed a training and internship program, while at the same time teaching English, interviewing language students and teachers, and observing applications of the approach to the teaching of English and French. The first part of this section will consist of accounts based upon information acquired and observations made during that 12-month period in both a private and a public instructional setting; these reports will be followed by a description of studies that I have conducted at the University of South Carolina, using as subjects students enrolled in elementary and intermediate French courses.

ately following one week of the foreign language training.<sup>14</sup> A tabulation of the course evaluations of 200 students showed that 98% of them believed that they were better able to comprehend the sounds of the foreign language after one week of intensive instruction, with 97% stating that they were satisfied with the results of the training. Given the seriousness and maturity level of the clientele, these percentages are very impressive. Although clients expressed satisfaction with the results obtained by the end of a week, they were encouraged to enroll in additional weeks of instruction in order to solidify what they had acquired, the most typical program involving 3 weeks of training.

### *Observations from 1994-95: The Tomatis Approach in a Public School Setting*

The *Atelier-Écoute* (Listening Workshop) directed by Mme Michelle Corrigo at the Collège Rutigliano in Nantes was one of four initiatives based on the Tomatis approach that were operating under the auspices of the French Ministry of Education during the 1994-95 academic year. The following account is based on an interview with Mme Corrigo and her colleagues in May of 1995 and on subsequent correspondence with her.

Mme Corrigo had introduced listening training to the Collège Rutigliano in 1989. At that time she provided training for only six at-risk students; by 1994-95, however, the listening workshop had been expanded to include both successful and at-risk students ranging in age from 11 to 16, the participants being chosen on the basis of a request either from their parents or from one of their teachers. At the end of the 1993-94 school year, there had been 90 requests, but only 32 students could be admitted because of scheduling constraints and limited space and equipment. Upon selection, each student was given a Tomatis Listening Test, and each was retested after every 30 hours of listening throughout the program.

The *Atelier-Écoute* that I visited was located in a classroom equipped with two Electronic Ears and eight headsets, permitting a maximum of eight students to listen at one time.<sup>15</sup> Students were seated around a large table and drew, worked puzzles, or did homework as they listened. Although a teacher was present, no instruction took place. Unlike the listening program at the Paris Centre, little individualized pronunciation practice was possible, there being only two microphones for the eight students.

The *Atelier-Écoute* consisted of an hour-long training period in the morning and a second hour-long training period in the afternoon. Of the 120 half-hour, cassette-based sessions mediated by the Electronic Ear, 32 were devoted specifically to learning English as a foreign language. Although no formal instruction took place during these sessions, English teachers at the Collège Rutigliano reported that they had consistently observed improved rhythm and intonation on the part of the participants after the listening training. They further stated that those students who had completed the program had less of a tendency to translate during oral language practice.

At the Centre in Paris, the Tomatis approach was tailored to the individual, with all language instruction being mediated by the Electronic Ear, whereas the

listening training that took place in Mme Corrigou's *Atelier-Écoute* was supplementary to the students' English course. Despite these differences, each program incorporated two essential components of the Tomatis approach: (1) an initial assessment of the individual's listening capabilities and (2) a listening training program mediated by the Electronic Ear. Further, the Tomatis Listening Test was given periodically in order to chart the learner's progress and to adjust the listening training in function of that progress.

### *Pilot Studies at the University of South Carolina*

Encouraged by European research on the application of Tomatis' theory to foreign language instruction and by the observations and interviews that I had conducted during 1994-95, I applied for and received a grant that funded the purchase in the fall of 1997 of the specialized equipment and materials needed for a small Tomatis training center.<sup>16</sup> This equipment, consisting of a Tomatis Listening Test System, an Electronic Ear, four Tomatis headsets, a headset control box, a microphone mixer, and recorded cassettes of the music of Mozart and of French language, was completed by a professional-quality cassette player and microphones furnished by the Foreign Language Learning Center.

During the spring and fall semesters of 1998, I conducted two small pilot studies in order to determine (a) the feasibility of providing sound perception training in the setting of a large public university in the United States and (b) the effectiveness of sound perception training in increasing the language acquisition potential of students enrolled in first-year French courses.<sup>17</sup> The program of listening training was based loosely on the program that is typical of foreign language training at the Centre Tomatis at the present time: 10 hours of preparatory listening (*phase d'intégration*); followed by 20 hours, consisting of 10 hours of a language course mediated by the Electronic Ear plus 10 hours of individualized training (*module intensif*); and a final 10 hours of training with the Electronic Ear, followed by 10 additional hours of classroom instruction (*module sémi-intensif*). The program at the University of South Carolina included 30 hours of Tomatis listening training; however, instead of 20 hours of foreign language instruction mediated by the Electronic Ear, students in the pilot tests were enrolled in a proficiency-oriented course, meeting 3 days per week over the semester. Since the Tomatis training was not a course component but rather a supplement to the students' language instruction, it functioned in much the same way as the language sessions of the *Atelier-Écoute* at the Collège Rutigliano. Another similarity with Mme Corrigou's program was that pronunciation practice and reading aloud were limited by the fact that, due to an incompatibility of the microphone mixer and the new model of the Electronic Ear, only one microphone was available for every four students.

Essentially the same scheduling, program, and procedures were followed in both pilot studies. Because of the busy schedules of university students and the availability of space, students were not able to attend training sessions daily. Rather, from a total of 12-13 two-hour sessions offered during a given week, they selected

three or four that suited their schedules. Some hours were more popular than others; so the number of students present at any given session ranged from one to four, with two or three being the norm. All students were obliged to follow the same cassette program; the only difference was that the students in the first study were enrolled in the second semester of the basic French course, whereas the students in the second study were enrolled in the first semester of the course.

Even though the two pilot studies were conducted primarily to determine the feasibility of introducing Tomatis training at the university level (space and scheduling, students' willingness to attend all sessions, students' reactions to the materials, appropriateness of level, etc.), students were given a second Tomatis Listening Test approximately 2 weeks after the end of the program<sup>18</sup> in order to evaluate the effects of the training. The results of these tests were submitted to foreign language consultants at the Centre Tomatis in Paris for their evaluation. These consultants did not know the students' names, nor did they know which tests were administered before the training and which after. They were simply given coded listening graphs and asked to assign to each a number that would reflect that student's language potential. In other words, every graph was evaluated as if it were the first listening test. Afterwards, each student's tests were placed in the proper sequence in order to determine if the student's language learning potential had increased. Four of the 5 second-semester students who completed the first pilot study (March 22 through April 14) received a higher rating on the second test. Results were similar for the second pilot study, which took place between October 15 and November 9, using volunteers from first-semester French. Again, the results of the evaluation from the Centre Tomatis were encouraging in that 5 of 7 students were seen to have improved. By combining the results of the two groups of first-year students, we observe that 9 of 12 were judged, in a blind evaluation, to have increased their language acquisition potential.

When the scores assigned in the evaluations are put into the context of students' self-report questionnaires, the outcomes of the two studies can be considered very positive. Of the 12 first-year French students who participated in the studies (5 in the first study and 7 in the second), 11 completed a self-report questionnaire at the end of the 30-hour program. All 4 students in the first study who submitted the questionnaire indicated that they found French easier to pronounce after the training; 3 of the 4 stated that it was also easier for them to comprehend oral French. Five of the 7 students in the second study cited easier pronunciation at the end of the program; 6 of 7 found that understanding spoken French was easier as well. To summarize, 9 of the 11 students who completed a final questionnaire reported improvement in both pronunciation and comprehension; the remaining students rated their ability in pronunciation and comprehension as "about the same." Only 2 students, one in each group, failed to complete the program. The first, a male engineering major, completed only half of the 30 sessions, citing the deadline for a project as his reason for withdrawing; the second, a busy mother, dropped out after two sessions because of family demands.

In the fall of 1999, Tomatis listening training was made available to intermediate students for the first time.<sup>19</sup> This was also the first time that the training had

been integrated into an existing language course rather than being offered as a supplement. The three instructors of French 210 (Oral Communication) agreed to allow the 30 hours of Tomatis training to replace the weekly listening journal required of all students enrolled in that course. The listening journal assignment requires each student to listen to at least 60 minutes of authentic French (radio and television broadcasts, films, etc.) during the first half of the semester and to at least 90 minutes of authentic French during the second half of the semester. Students report on their listening strategies and evaluate their progress in weekly journal entries submitted to the instructor.

After an administration of the Tomatis Listening Test to 14 volunteers from the three sections of French 210, students were randomly assigned to the Tomatis listening training group or to a control group made up of students who agreed to take a second Tomatis Listening Test after the training period, even though they would not participate in the training. The scheduling, program, and procedures for this group were the same as that of the two 100-level pilot studies described above, except that, during the microphone sessions, each student read or repeated into an individual microphone of high quality. Students in the experimental group completed 30 hours of cassette-based training, including music and French language, by mid-semester. They did not keep a listening journal either during or after the Tomatis training. Students in the control group listened throughout the semester to authentic French from a variety of sources and turned in a weekly journal. Both groups of students were exposed to authentic French video during class sessions.

All students in the three sections were given the same 100-point, video-based, multiple-choice listening test as part of their final examination. A comparison of the scores of the two groups slightly favored the Tomatis group (Tomatis  $x = 87.5$ ; control  $x = 84$ ). While the difference is slight, it does indicate that students were not disadvantaged by participating in the listening training program rather than by submitting weekly listening journals. Blind analysis of the students' performance on the Tomatis Listening Test (25 points) by a specialist at the Paris Center revealed that students in the Tomatis group had increased their score by an average of 3 points (range 2-4) between the first test and the test given after 30 hours of listening training, whereas students in the control group had increased their score by only 1.16 points (range 0-2).<sup>20</sup>

Although they do not relate specifically to language learning, incidents reported by participants in two different studies are worthy of note. Each of these students was taking voice lessons at the time of the Tomatis training. The first, a female from the first group, reported that her voice teacher, who was unaware of the listening training program, had commented on the fact that she was able to imitate musical sounds more accurately and to memorize them more quickly when learning a new piece of music. A male student in the third Tomatis study related a similar incident. After the second week of training, he enthusiastically described his latest piano and voice lesson. During that lesson, the teacher had played various series of random notes on the piano and asked him to sing them. For the first time in years of voice training, he made not a single error. Similarly, when the

teacher sang several series of notes and asked him to reproduce each series on the piano by ear, he did so perfectly. These independent and totally unsolicited evaluations of sung language do not necessarily indicate that the two students in question improved their foreign language ability; they do, however, indicate that listening training has an effect on the voice as well as the ear.<sup>21</sup>

## Conclusion

During the past 20 years, the foreign language teaching profession has become increasingly aware of the importance of listening in language learning. As stated in the first section of this paper, the Tomatis theory of language acquisition, which emphasizes listening training, has much in common with the comprehension approaches and is consonant with the current professional interest in listening, not only as an important communication skill but also as a crucial variable in foreign language learning. Like the proponents of the comprehension approaches, Tomatis believes that the ear is the key organ for language acquisition and that a phase of receptive language training should precede production. Further, Tomatis' insistence on the importance of the desire to listen is in agreement with the Affective Filter Hypothesis. Likewise, the Linguistic Coding Deficit Hypothesis, which states that some students who underachieve in foreign language classes do so because of phonetic coding problems in the first language (Sparks and Ganschow, 1993a), coincides well with Tomatis' belief that successful foreign language learning must be based on accurate speech perception. We may conclude, then, that some aspects of the Tomatis approach agree, at least in theory, with hypotheses concerning foreign language acquisition advanced by influential scholars in this country.

We have seen too that the Tomatis approach has been implemented successfully in Europe with adolescents and adults in both public and private instructional settings. In addition, it has been tested empirically in school settings at both the secondary and university levels with highly positive outcomes. My own research, which is on a very small scale and is still in the embryonic stage, has, nevertheless, produced encouraging results in a large public university in the United States. Future studies at the University of South Carolina will examine the long-term effects of Tomatis listening training at different levels of language instruction and will include measures of oral production as well as comprehension.

Certainly, more empirical investigation is needed before we convert today's language laboratories into Tomatis listening training centers; however, given the facts elaborated above, we as a profession should not overlook the potential of Tomatis listening training for aiding not only the special cases identified by Kaunzner (1997, pp. 9-10) but also the average language learner. While not "new" in the strictest sense of the term (Tomatis established the first "ethnograms" in the 1950s), the Tomatis approach has evolved and will continue to do so as new research findings become available and new technology facilitates its implementation.<sup>22</sup> This "old" but evolving approach merits our consideration as a promising "new" direction in foreign language instruction.

## Notes

- <sup>1</sup> This professional debate has renewed interest in earlier studies of learner variables, including that of Pimsleur, Sundland, and McIntyre, who in the 1960s identified auditory factors as contributing to underachievement in foreign language study.
- <sup>2</sup> The article by MacIntyre, for example, is an argued response to Sparks and Ganschow.
- <sup>3</sup> For a general description of the role of listening in learning disabilities, see Thompson (1993).
- <sup>4</sup> Tomatis' first "law" is that the voice contains only those sounds that the ear is capable of hearing.
- <sup>5</sup> Dr. Craig Ramey, Professor of Psychology, Pediatrics, Neuro-Biology, and Maternal and Child Health at the University of Alabama at Birmingham, the keynote speaker at the 2000 SCOLT conference, emphasized the importance of exposure to a wide variety of phonemes at an early age, so that the ability to reproduce these phonemes would not disappear.
- <sup>6</sup> In one recent article (Thompson and Andrews, 1999), the work of Tomatis is described as pioneering and foundational for an entire emerging field of sound training. The area of foreign or second language is recognized as one of the application types served by this field.
- <sup>7</sup> Bone conduction is a normal part of the hearing process. Transmission of sound through bone, however, is much faster than through air. The speed of sound transmission in meters per second is as follows: dry air, 0° C - 353 m/sec; bone - 3,380 m/sec (Lide, 1993).
- <sup>8</sup> In this part of the test, students are asked if the sound they have just heard is higher or lower than the one just before it. The sounds range from 125 Hz to 8000 Hz.
- <sup>9</sup> Rhythm was measured by means of the Stambak test, which requires subjects to listen to and reproduce 21 rhythmic sequences, each more complex than its predecessor. Pronunciation was evaluated by an impartial British judge, who listened to students from both groups pronounce complete sentences.
- <sup>10</sup> Since the report of the authors may be difficult to obtain in this country, the reader is referred to Tomatis' account of the experiment in chapter 8 of *Nous sommes tous nés polyglottes* (1991).
- <sup>11</sup> These were the Katholieke Vlaamse Hogeschool (Belgium); the Gerhard-Mercator-Universität-Duisburg (Germany); Università La Sapienza (Italy); Università Cattolica del Sacro Cuore di Milano (Italy); Universidad de Zaragoza (Spain); and the principal investigator's home institution, the Università di Bologna (Italy).

- 12 There were two comparison groups. A “zero” group took regular university courses, whereas a control group worked in a conventional language laboratory under the direction of a teacher who corrected the students’ performance. The materials used by the control group were identical to those used by the SPT group.
- 13 Chapter 9 of the Depardieu biography listed in the references describes the actor’s experience with Tomatis.
- 14 It is important to keep in mind that these “weeks” normally involved 4-hour sessions daily for 6 days, plus additional individual listening on Sunday.
- 15 Only four headsets can be plugged into the headphone control box, which in turn is plugged directly into the Electronic Ear.
- 16 This equipment was funded by a University of South Carolina Venture Fund grant and was purchased from Tomatis International, 21bis, rue Lord-Byron, 75008, Paris.
- 17 Because 3 years had gone by since my initial training, the pilot studies also enabled me to reestablish my skill in administering the Tomatis Listening Test and operating a new model of the Electronic Ear.
- 18 This delay allows the students to integrate the results of the training before being tested.
- 19 Because the incompatibility of the new model of the Electronic Ear and the microphone mixer made it impossible for each student in the group to speak into a separate microphone, Tomatis training was suspended during the spring semester of 1999 so that a solution to the problem could be found. This was done, permitting the continuation of the study.
- 20 More detailed information about the South Carolina studies will be presented elsewhere in a research-oriented article.
- 21 My husband, Buford Norman, tone-deaf for 45 years, can now whistle and sing on key as a result of Tomatis listening training in the fall of 1994.
- 22 A model of the Electronic Ear now in development will be operated by means of a smart card onto which the student’s listening program is encoded.

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