Colloque des 10 et 11 Mars 1997:

"Audio-Lingua": pronunciation improvement through sound perception training

When learning a new language, various components have to be considered: grammar (morphology and syntax), lexicon and phonetics. Whereas in grammar and lexicon considerable progress can be made in a cognitive way (e.g. through the study of texts and memorisation), this is not the case with sound discrimination ability and, consequently, pronunciation and intonation. Here adult learners feel they face an insuperable barrier.
The importance of listening in language learning and its role in helping the learner overcome this barrier has long been recognised. Indeed, there is hardly an institution without a language laboratory or tape-recorders. But we also know from our own experience that there are cases when students simply do not succeed in producing words or sentences correctly even after hours in the language laboratory. Is it because they just fail to reproduce the correct sounds or is it possible that they do not hear them correctly? Voice production is closely connected to auditory comprehension. This means that pronunciation problems are not always articulation problems and, therefore, pronunciation exercises can be of little help if, from the very beginning, the auditory input is not being decoded correctly. Consequently, how can traditional pronunciation training help if the student keeps hearing sounds incorrectly? Pronunciation exercises should, therefore start with a battery of exercises aiming at sound perception training!

Audio-Lingua" is the name of a research project which tested the efficiency of the SPT method ("Sound Perception Training"). This method proved to have clearly positive effects on oral production (pronunciation and intonation) of the target language. The project was supported by the European Union through the Lingua Programme, which is now called the Socrates Programme, and the support lasted for the maximum three years (1993, 1994 and 1995). The project had two goals:

1. to test the efficiency of the SPT method in terms of pronunciation improvement through acoustical stimulation;
2. to develop didactic pronunciation material (book with tapes/CD) for the target languages German, Italian, Dutch and Spanish.

Apart from the co-ordinating institution, the University of Bologna (School for Interpreters and Translators in Forlì), a further five universities and two non-university institutions in Italy, Germany, Belgium, the Netherlands and Spain collaborated.[1]

1. Listening and language learning: the principles of the SPT method ("Sound Perception Training")

The SPT method aims at making people more perceptive to the sound system of the target language. Since comprehension is always ahead of production, aural comprehension is ahead of oral production. The results of our project have confirmed that students who undertake this training have a far better pronunciation than those who work with pronunciation exercises only.
Alfred Tomatis, the French specialist in ear, nose and throat diseases, carried out research on sound perception mechanisms in the 1950s. He compared voice spectra (spectrograms) with listening

curves (audiograms) and found a close correspondence between the distribution of Hz-frequencies[2] for hearing and production. Those frequencies which could not be perceived by the ear were also missing in the voice spectrum[3]. For a non-defective ear this means that there is an automatic selection in the registration of auditory input, which is revealed in the quality of voice production[4]. The auditory selection can be **voluntary**, for example when we succeed in understanding someone in a very noisy environment (where, if one measured it, the volume of the noise might be higher than the voice we are trying to understand)[5]. The auditory selection can also be **habitual**, for example, a mother might sleep through all kinds of noises, but when her baby merely whimpers, she is immediately wide awake. Someone else might not even be aware of this sound because they do not attach any meaning to it.

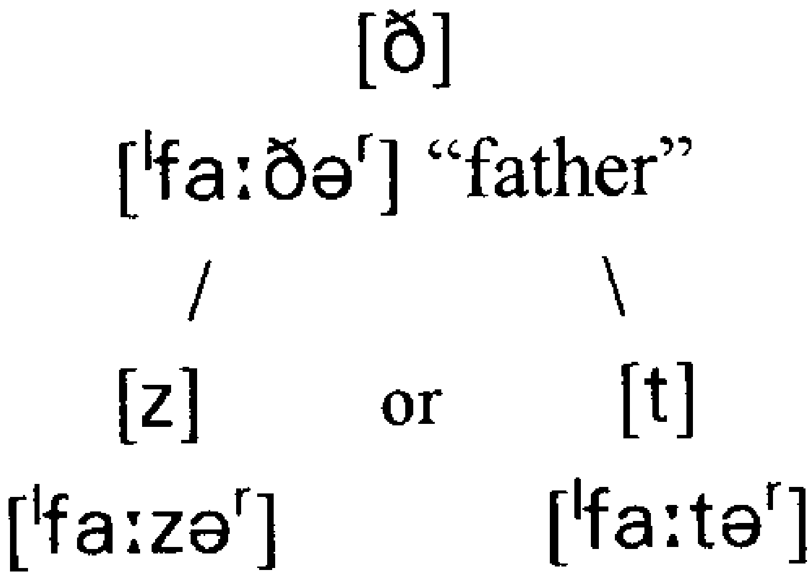
One encounters the same phenomenon of selective hearing when learning a foreign language. Our auditory system for languages

is strictly connected to the specific language(s) we are brought up with: namely, our mother tongue or, in the case of bilinguals, our "parent" or "caretaker" tongue(s)[6]. Tomatis calculated "envelope curves" for different languages, which show the characteristic mean frequency spectrum of a language[7]. Other scientists, such as Delattre, made similar calculations and compared differences in vowel formants in various languages[8]. Certain foreign language sounds which do not exist in one's mother tongue are heard and interpreted in the closest way they come to these sounds in the listener' own native language sound inventory. This substitution strategy is one of the main reasons why the learners of a foreign language speak the language with a "foreign accent". Often, they do not even realise this: their mental decoding mechanism does not react to certain unfamiliar foreign language sound systems.

Young children do much better than adults in terms of phonological development. When acquiring more than one language at a time, they have no "foreign accent" in any of the languages. Adult learners (learners in the so-called post-critical phase, from puberty onwards) have great difficulties with new sound systems. In fact, in other areas, such as grammar or vocabulary, it has been shown that older learners do better because of their use of cognitive skills[9]. In pronunciation, cognitive help is useful only up to a certain degree (e.g. through visualisation of the speech organs, melody curves, verbal description of the production of certain sounds).

Correct pronunciation can only rarely be achieved automatically or by mere imitation. Adult learners already have fossilised listening habits and not everything which is heard can be reproduced correctly because the sounds of the foreign language pass through a filter which consists of the sound inventory of the mother tongue[10]. The language laboratory is of limited use if students are not able to hear correctly, i.e. if they are not able to discern unfamiliar sound patterns. New listening and hearing habits have to be developed in order to improve productive competence. These new listening models can then control and correct one's sound production and train the speech apparatus.

As a result of the above-mentioned differences in language perception, a speaker of one language will not necessarily perceive and decode all the phonological input from another language, and, consequently, will not be able to encode it into oral production either. For example, the German phoneme /ö/ (as in "böse") does not exist in many languages and is often substituted by the sound which comes closest to it in the learner's own language through the generalisation of sound patterns: either /e/ ("bese") or /o/ ("bose"). Indeed, differentiation tests[11] have shown that a large number of students who make errors in this kind of speech production cannot easily differentiate the sound when presented acoustically. The same is true for other sounds or sound combinations which the learner is not familiar with. Another example is the English fricative [—] as in "father". Germans frequently have problems with this sound and substitute it with a sound from their own sound inventory - [z] or [t] - which comes close to it:.



omatis developed an electronical instrument (which he called "electronic ear") that helps to stimulate sound perception capability and thereby increase the amount of perceived information. Improved sound perception leads to an improvement in listening ability, to a better comprehension of the language in general and better language production (e.g. pronunciation), i.e. language learning is facilitated. The electronic ear educates the automatic auditory selection mechanism and trains the ear to react in order to perceive unfamiliar sound patterns. In this way, it modifies one's way of hearing and hence one's way of speaking. This instrument, is called "Sound Perception Trainer" or "SPT" and completed with sound-sources (microphone, tape player)[12] and special headphones.

2. Modifications of sound by the SPT instrument

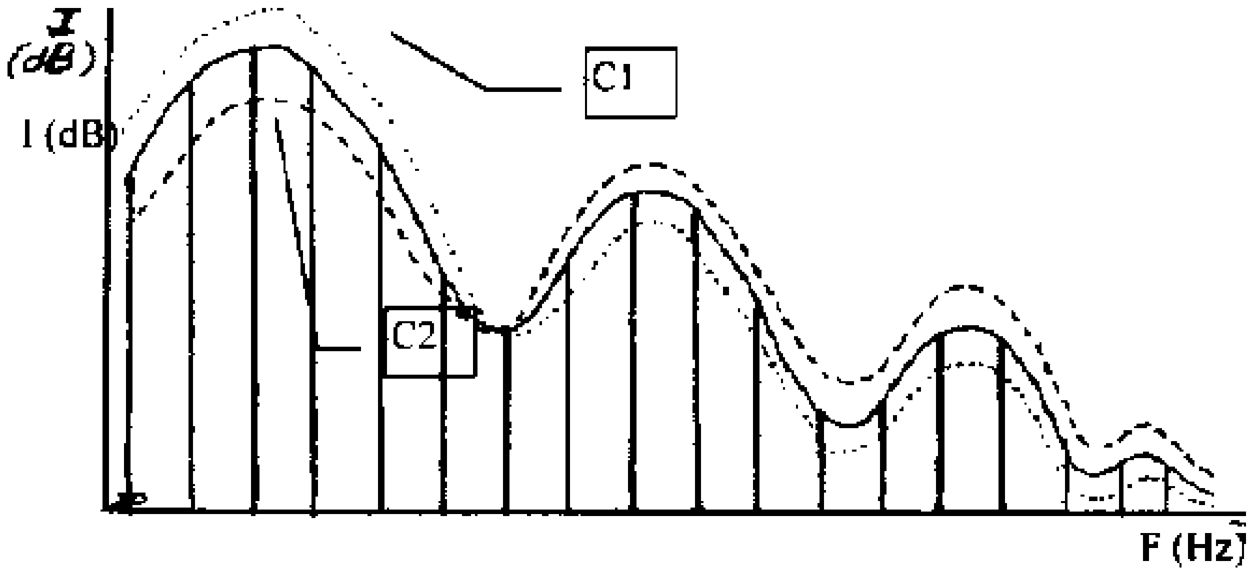
The training, as developed by Tomatis, re-educates the ear's organs so that the innate listening abilities are stimulated. This occurs by means of the electronic modification of the sound and sound transmission. The SPT can be programmed either individually or for homogeneous groups in accordance with the following four modifications:

2.1 Filtering

For the pure recognition of vowels, only the main formants (the lower formants) are important[13]. The differences in the timbre of voice, on the other hand, lie mainly in the higher zones, especially in the secondary formants. They do not carry phonemic information and tend to be overshadowed by the strong main formants so that fine differences are not perceived. Through filtering from low to high frequencies (from 500 to 9,000 Hz), the learners are taught to become perceptive in the area of the overtones and to learn to distinguish sounds better.

2.2 Transmission of sound through two channels

The instrument uses two channels for the transmission of sound[14]. The sound structure in channel 1 (C1) enhances the frequency profile of the learner's way of speaking and hearing: lower frequencies are strengthened, higher ones weakened. In channel 2 (C2) the opposite occurs: the lower tones are weakened and the higher tones strengthened. By means of sudden "jumps" between the two channels, the ear is forced to adapt to the unfamiliar sound structure of the target language and the automatic selection mechanism described above is eliminated.



2.3 Bone conduction of sound

The headphones of the SPT have an additional transmitter for the bone conduction of sound in order to intensify sound perception by directly leading the sound vibrations to the inner ear through the skull. In this way there are three sources of sound transmission: the right ear, the left ear and the bone transmitter on top of the skull. Sound not only travels through the air, it also travels almost ten times faster through dense material like bone[16]. In the hearing/listening process, sounds are always received through bone <u>and</u> air conduction[17].

2.4 Intensity differentials in the output

The volume with which the manipulated sound message reaches the students' ears differs from one transmitter to another. It is especially reduced in the left ear. This modification is made because the two ears do not receive sounds in the same way. According to Tomatis, the right ear has a dominant function: it controls and guides the aspects concerning intensity, timbre, intonation, melody and semantics[18]. One reason for the right ear's dominance is that the length of the nervus recurrens, the part ofhe nervus vagus which controls the tympanum, pharynx and larynx, is 40 to 50 cm longer on the left side than on the right. This means a remarkable delay of the nervous signal[19].

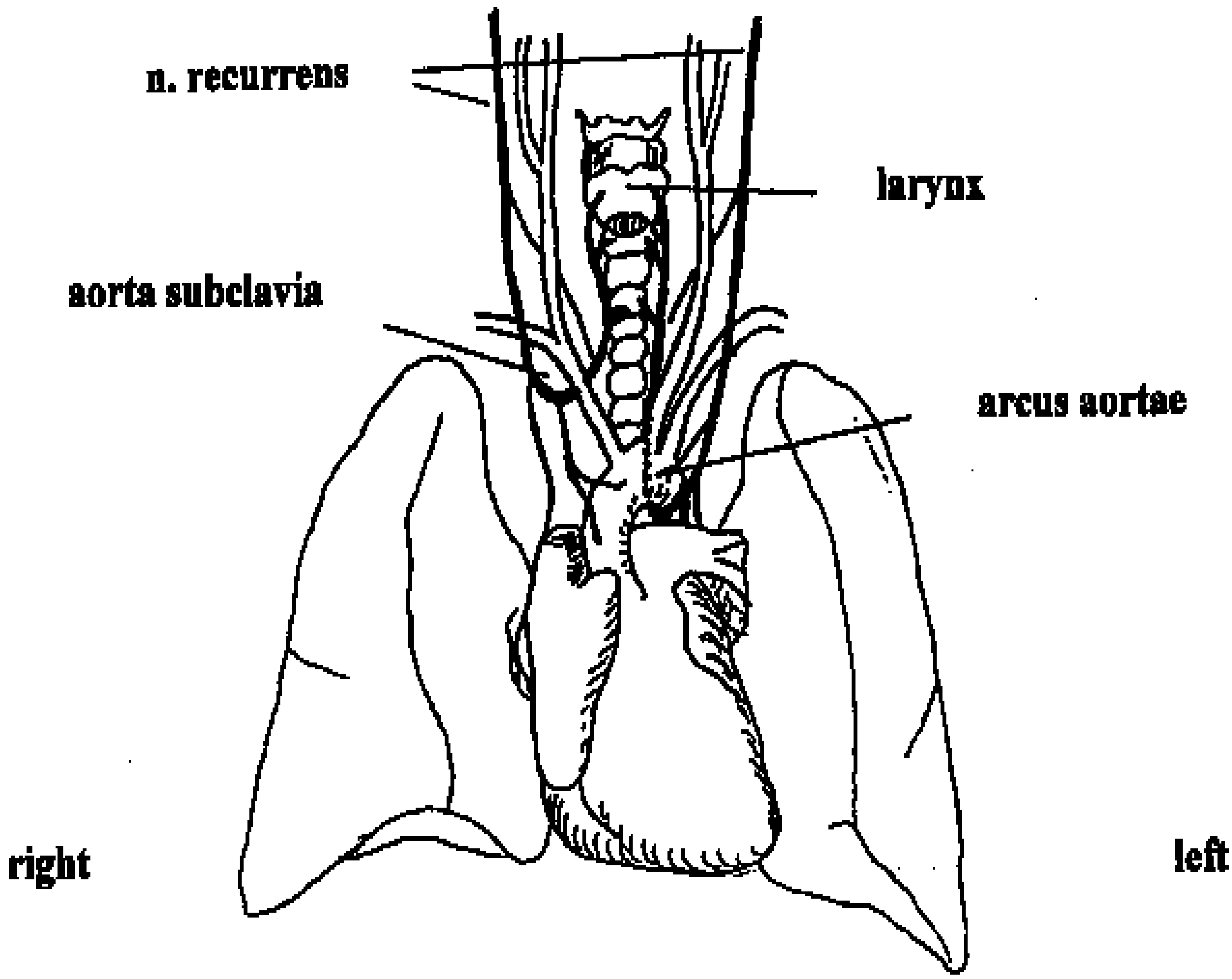


Fig. 2: Abdominal part of the nervus vagus: the two recurrens nerves

Tomatis gives another reason for the preference for the right ear during the training with the apparatus: the areas of the brain responsible for the analysis and recognition of speech, and the processing of phonetic information when acoustically presented are in the left hemisphere. Signals perceived by the left ear would first arrive in the right hemisphere and then be sent to the left for decoding. This means a loss of quality if the speaking process is controlled by the left ear[20].

3. Set-up of the SPT training programme

The sound perception training programme precedes or accompanies conventional language study. It is not meant to be a competitive or substitute approach - it is a complementary or remedial one aimed at overcoming the barrier of acquiring the correct pronunciation. After a certain number of listening sessions, the training is complete and should not lose its effect over time. The SPT should be seen as an instrument for the correction of rigid listening habits, educating the automatic auditory selection mechanism which modifies hearing and hence speaking. The training, therefore, provides a "shortcut for learners" (McLaughlin, 1987, p. 48).

Fig. 3: Circle of effects

The training which first stimulates the listening ability and is then integrated into pronunciation exercises needs to follow a regular schedule. Each session, which takes place on a daily basis, lasts a minimum of 60 and a maximum of 120 minutes (120 minutes turned out to be too long for students who have to find spare time in their university schedule). The total time involvement is around two months, but this can be extended if necessary.

Our training programme uses pronunciation exercises and texts which were developed within the "Audio-Lingua" project[21]. It is divided into two stages. The students start with a receptive stage and then proceed to a productive stage after a pause of two to three weeks. During the **receptive stage,** the learners listen to tapes with texts in the target language. The SPT performs the modifications mentioned above. The learners are not always consciously aware of these modifications, but the SPT forces their ear to "open up" to unfamiliar sounds.

During the **productive stage**, the students listen to recordings in the target language (words, phrases, sentences and short texts), repeat them and also read aloud themselves. While they are repeating or reading, the SPT instrument is constantly adapting their ears – and thus their voices – to the typical frequency spectrum of the target language so that the training has a double effect: It affects both listening and speaking and gives the students the possibility of self-monitoring. The students learn to experience how a native speaker of the language they are studying hears the language, and this gives them an advantage over someone who tackles it with only his/her own ethnic sound inventory to rely on. During and after the training, students are more likely to speak with the correct pronunciation and intonation of the foreign language.

4. Testing of the SPT method within the "Audio-Lingua" project

The study was carried out in five universities with three testing groups, all students of German: Forlì, Antwerp, Saragossa, Milan and Brescia. In all universities the same material was used (German as a target language[22]) since German was the first pronunciation course to be developed within the project and in this way the results are comparable. Potentially, the results can be transferred to any target language and any source language. The three testing groups had the following profile:

1. **PT group: The students worked with the SPT instruments using the pronunciation material developed within the project (German as a target language). A teacher was only occasionally present but did not intervene or help.**

2. **Control group**: The students worked in a conventional language laboratory with the same material (German as a target language, as developed within the project), but without any sound manipulation. Here, a teacher was <u>always</u> present, and controlled and corrected the students' performance. – Saragossa did not have a control group.
3. **Zero group: The students of this group did not undergo any specific pronunciation training, they merely carried on with their everyday university courses in German. – Forlì did not have a zero group. S**

All students of all three groups underwent an initial and final test; the experimental group took an additional interim test. Initially, there were 203 people; by the end, the number was reduced to 158, 128 of which were regarded as statistically significant[23]. All tests consisted of a listening test (sound perception threshold, selectivity and laterality), a "receptive test" (phoneme differentiation, multiple choice and word stress tests) and a "productive test" (reading aloud, repetition and free speech)[24].

listening test	• **sound perception threshold** • **selectivity** • **laterality**
"receptive "test *(in the language lab)*	• **phoneme differentiation** • **multiple choice (sound discrimination)** • **word stress**
"productive" test *(individual test, tape recordings for segmental and suprasegmental evaluation)*	• **reading aloud (dialogue and prose)** • **repetition** • **free speech**
questionnaire	• **student's own impression**

Fig. 4: Tests which all participants had to undergo

5. First results

The Dutch testing institute CITO helped with the set-up of the tests and is evaluating the test results using the one-parameter Rasch model[25] which is a model from the Item Response Theory (IRT). The Rasch model specifies a relationship between observable test performance and an unobservable trait or ability assumed to underlie this performance[26].

Each of the tests was assigned 248 items[27] for statistical evaluation. Each single item was given an attribution which encodes the result of the students' performance on the single item (the total data set is over 1,600 item-person encounters). By applying the IRT model, the relationship between the observable result of a test and the ability of the person undergoing the test can be calculated[28]. The difference in this variable between the ability of a subject and the difficulty of an item determines the probability of a correct response. Thus the elaborated test results can be described in ability scores, which are closely connected to the linguistic competence of the participant. Even though CITO is still working on the preparation of the final report, in which single aspects of the overall results will be looked at, compared and discussed, they have so far produced figures which visualise the overall results (all the tests together) on an ability scale, which shows the students' ability to learn or make progress in the foreign language on the basis of their test results. The following table shows the evaluation of the linguistic ability of the participants in T1 (initial test), T2 (interim test, only in Forlì) and T3 (final test)[29]:

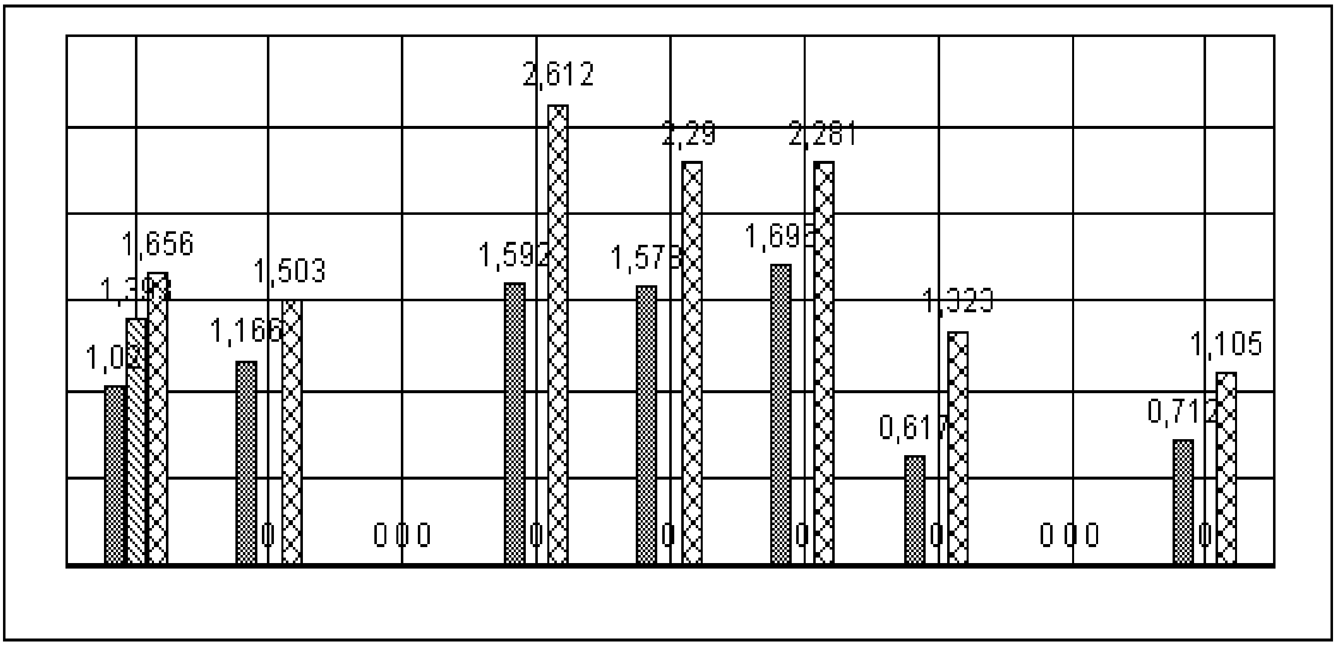


Fig. 5: Evaluation of the linguistic ability of the participants

Results show that in all the testing groups at all partner universities, the SPT training led to an increase in phonetic ability, with the SPT groups showing a significant advantage in comparison to the control groups and the zero groups.

Let us take a closer look at the growth in the ability score of the single groups in Forlì, Antwerp and Saragossa:

Forlì growth	SPT group: 62.35 %,	control group: 28.90 %
Antwerp growth	SPT group: 64.07 %,	control group: 45.12 %
Saragossa growth	SPT group: 114.42 %,	zero group: 55.20 %

The high numbers in Saragossa probably result from the fact that the level of German of both groups was very low to start with. This led to a faster improvement than in Forlì or Antwerp (both schools for interpreters and translators).

When comparing the overall results of the SPT groups and the control groups at T 1 (initial test) and T 3 (final test, about three months later), the results provide an impressive picture: in general, the ability of the SPT groups increased by 70.95 % whereas the control groups had a mean increase of 36.52 %:

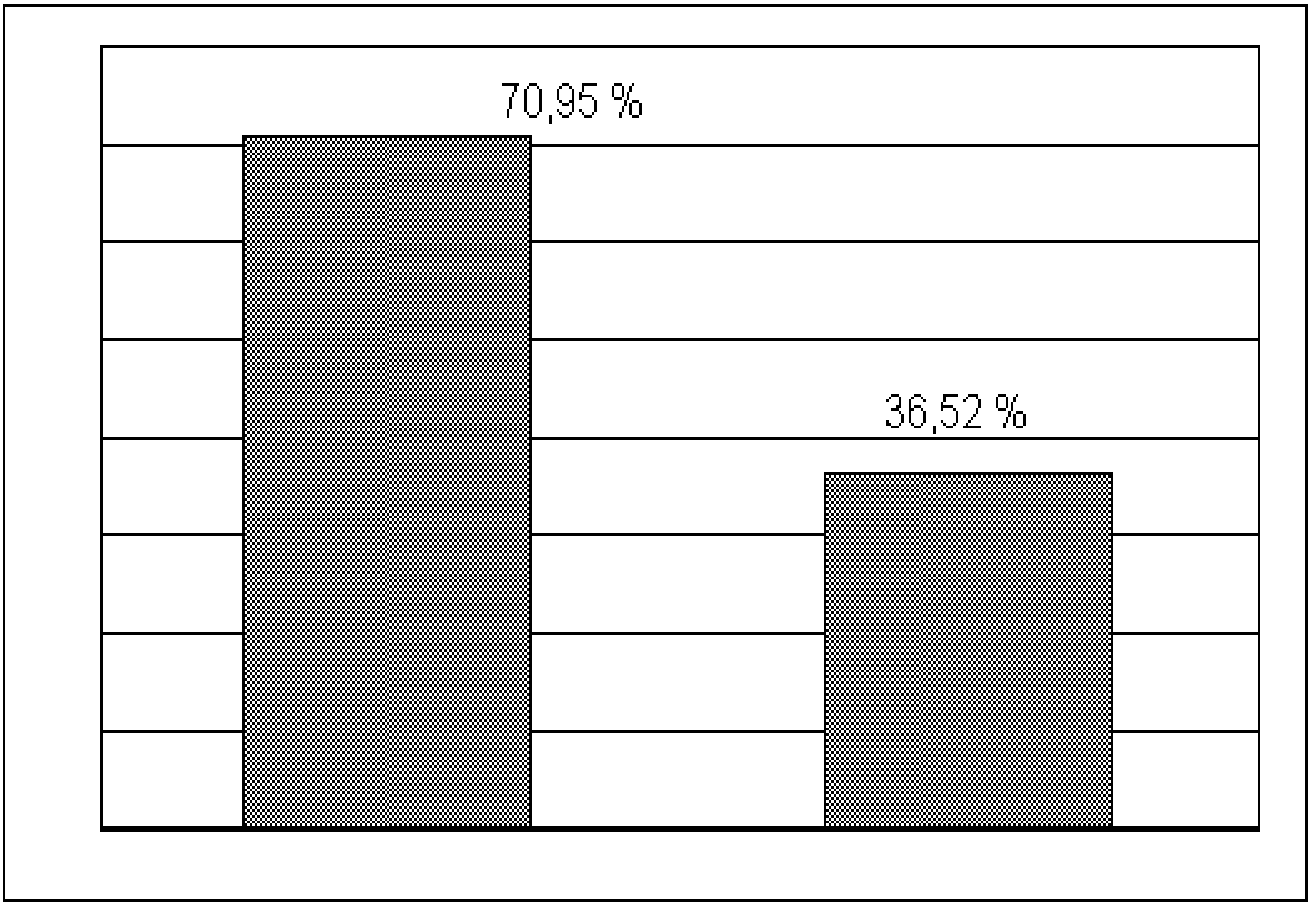


Fig. 6: Ability increase between T 1 and T 3 of all SPT and control groups

These results show clearly that the method might mean a remarkable innovation in foreign language learning and teaching. If transferred into time units, a student working with the SPT method would be able to achieve the same results in almost 50 % less time as someone from the same course who worked without any specific sound perception training.

6. Conclusion

The test results show that so far students who undergo the SPT training have a significantly better pronunciation than those who work using only pronunciation exercises. Sound perception training turned out to be a valuable instrument to support and facilitate language courses and to accelerate oral production ability. It may be of considerable help in a multilingual comprehension approach because the training literally "opens up" the ear and the learner acquires greater sensitivity towards auditory input in general.

Four groups of learners in particular may be able to profit from the SPT method:

1. Adult learners, who are known to have more difficulties than children in learning foreign languages in terms of pronunciation and intonation;

2. Advanced learners who already have a high level of language proficiency and see themselves at a level from which they cannot progress without additional help;

3. Isolated learners who have to learn a language autonomously, without the presence of a (native) teacher or the possibility to spend time in the country of their target language.
4. Young learners with special hearing difficulties (remedial teaching).

It is also believed that average learners, at whatever stage of proficiency, can greatly profit from systematic or occasional training with the materials developed for the SPT[30].

Footnotes

[1] Our partner universities were:

1. Katholieke Vlaamse Hogeschool (Antwerp, Belgium)
2. Gerhard-Mercator-Universität-Duisburg (Duisburg, Germany)
3. Università La Sapienza (Rome, Italy)
4. Università Cattolica del Sacro Cuore di Milano (Milan and Brescia, Italy)
5. Universidad de Zaragoza (Saragossa, Spain)

The partner universities tasks were:

- to test the SPT method;
- to develop pronunciation material for the target languages German, Italian, Dutch and Spanish.

The names and tasks of the two non-university institutions were:

1. Diapason Ltd., Milan, Italy, which provided us with the electronic instruments and the technical know-how;
2. CITO (National Institute for Educational Measurements), Arnem, Netherlands: consultation in the setup of the tests and the evaluation of the data and test results.

[2] Frequency means the number of sound waves per second and is measured in Hertz. The higher the frequency, the higher the sound. A human ear can perceive from 16 up to 16,000 Hertz (sometimes 20,000 Hertz: cf. v. Essen 1979, p. 152)

[3] See the research by M. Pierre and P. Grassé , presented by R. Husson , 1957.

[4] To give some figures: according to J. Wendler and W. Seidner (1987, p. 86) total auditory registration is ca. 100,000 bit/sec, whereas the auditory perception is 50 bit/sec, which is only a 2,000th of the total information.

[5] Psychologists call this phenomenon of auditory selection "cocktail-party effect"

[6] Studies show that after three months a baby starts to form a listening pattern which is fully developed by the age of 16 (Caneau 1992, pp. 19, 39).

[7] Cf. Tomatis, 1991.

[8] Cf. Delattre, 1965.

[9] As Krashen says, the adult learners' poorer language acquisition ability results in a high affective filter, which works as a barrier against acquisition. Adults use a cognitive controlling instrument, which he calls "monitor". (Krashen, 1985)

[10] In the 1950s, Nicolay Trubetzkoy talked about "phonological grids" which function as filters: unknown sound characteristics of the foreign sound system would pass through the grid (which means that the decoding mechanism fails) whereas those familiar to the learner would be "held up". (Trubetzkoy, N.S. *Grundzüge der Phonologie*. Göttingen: Vandenhoek & Ruprecht, 1958)

[11] The kind of differentiation tests which were taken by the students at the University of Bologna were, for example, rows of words which differed slightly. The student had to indicate the one which sound different from the others, e.g. "Miller - Müller - Miller - Miller", where the right answer would have been a mark at the second position.

[12] Sound sources can be tape recordings as well as the learner's own voice (which immediately reaches the learner's ears through the headphones via a microphone and an automatic circuit).

[13] In the spectra of vowels, the main formants of the vowels are located in the following areas: /i/: 200 - 400 and 3,000 - 3,500 Hz; /e/: 400 - 600 and 2,200 - 2,600 Hz; /a/: 800 - 1,200 Hz; /o/: 400 - 600 Hz; /u/: 200 - 400 Hz. (Cf. Trendelenburg in Habermann 1986, p. 77).

[14] Two channels do not mean that one channel is used for the right ear and the other is used for the left ear. The sound is being modified constantly but not synchronized on both sides through the two channels.

[15] I indicates the intensity of sound, which is measured in decibels (dB), F stands for frequency, which is measured in Hertz (Hz).

[16] D.R. Lide compares numbers for the speed of sound transmission in meters per second: (Cf. Lide, 1993)

dry air, 0°C - 353 m/secsea water, 25°C - 1,531 m/sec bone - 3,380 m/sec

We can easily test bone conduction in our own body when we put our fingers in our ears and speak aloud. Everything we hear is mainly transmitted by the bones of our skull and not through the air. We are always used to hearing ourselves in a combination of bone transmission and air transmission. That is why tape recordings of our own voice sound so strange to us. In the latter case the bone conduction is mainly eliminated.

[18] For lateralisation of the hearing process see Tomatis, 1986, pp. 64-85.

[19] Cf. Kahle et al., 1991, pp. 108-09.

[20] Cf. A. Tomatis, 1977, p. 86 and Wirth 1994, pp. 76-88.

[21] Cf. Kaunzner, 1994, pp. 72-73 and Kaunzner/Gianni, 1997.

[22] The textbook (with 5 audio cassettes) for Italian native speakers is now available: U.A. Kaunzner, 1997. *I Suoni del Tedesco. Deutsche Aussprache für italienischsprachige Lerner*. Bologna, CLUEB. A general version on CD (for any source langage) is in print by Julius Groos Verlag, Heidelberg

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[23] There were several reasons for excluding some of the participants and for not considering Milan and Brescia at all:

1. organizational problems;
2. technical problems with the instruments (which turned out to need further improvement in order to be used with large groups);
3. the fact that some participants could not follow the whole set of sessions or missed the final tests.

[24] For a more detailed description of the testing material see Kaunzner/Gianni, 1997.

[25] Cf. Rasch, 1980.

[26] If the applied model holds true for all items in a particular set, all items measure the same ability, and a subject of higher ability will have a higher probability of a correct response for all items in the test than a subject of lower ability. Similarly, the positive differences in mean ability between groups of subjects will result in positive differences in probability for these groups to succeed in each and every item in the test. The computer programme OPLM (Verhelst et al., 1995) is being used to estimate the item difficulty parameter, given the data set. By using the conditional maximum likelihood (CML) estimation procedure, it was possible to estimate the item parameters without any constraint on the ability distributions within each group or across groups. (John De Jong, Director of the Language Testing Unit in CITO, final report in preparation).

[27] "Item" means a single aspect in a test which is evaluated (for example, whether the sentence stress in one of the repetition exercises is being repeated with the stress on the right word).

[28] John De Jong, Director of the Language Testing Unit in CITO, final report in preparation.

[29] By applying Item Response Theory, differences in scores between the groups at T1 become irrelevant.

[30] A detailed report on the test results will be published by CITO by the end of 1997.

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