Feedback in Computer Assisted Pronunciation Training: When technology meets pedagogy

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Abstract

This paper is organized around two main endeavours. On the one hand, we examine currently available Computer Assisted Pronunciation Training (CAPT) systems with a view to establishing whether they meet pedagogically sound requirements. In this respect, we show that many commercial systems tend to prefer technological novelties to the detriment of pedagogical criteria that could benefit the learner more. On the other hand, we more narrowly focus on the crucial issue of computer-generated feedback, which still represents a big challenge for state-of-the-art CAPT technology and discuss its impact on learning. In the final part of the paper, we present the PROO project (Programma voor Onderwijsonderzoek), which is aimed at establishing the effects of erroneous feedback on the acquisition of L2 pronunciation.

1. Introduction

In the last decades, second language (L2) teaching and learning have been dominated by communicative language teaching methods and interactionist theories. Since the adoption of these approaches, interaction has become paramount in teaching programmes and courseware products both as the learning aim and as the best tool to develop the learner's L2 communicative skills. Although it seems obvious that pronunciation should play an important role within such a language curriculum, the training of this skill is still often neglected within traditional L2 classroom instruction.

The reasons for this are several. On the one hand, some misconceptions about the possibility of successfully teaching L2 pronunciation have made research on this field less attractive than, for instance, research on grammar or vocabulary acquisition. As a result, few empirical studies are available on pronunciation training and clear pedagogical guidelines that could be used by language educators are still lacking. On the other hand, when designing a pronunciation-training programme, one has to reckon with practical constraints. For the student, learning pronunciation ideally requires prolonged supervised practice and interaction with native speakers; for the teacher, it ideally implies intensive interaction with the student and the provision of feedback on individual problems. These tasks are extremely time-consuming and difficult to implement in class-based settings.

Computer Assisted Pronunciation Training (CAPT) seems to offer a solution to the problem of practical constrains. CAPT systems allow students to access virtually unlimited and realistic L2 input through different channels, to practise individually as often as they wish, and to enjoy unlimited patience from the tutor. Moreover, through the integration of Automatic Speech Recognition (ASR) technology, these systems can provide individualized feedback automatically and instantaneously.

However, just like with traditional pronunciation training, these learning environments are only effective provided they follow sound pedagogical guidelines, while it appears that few of the available systems meet such requirements (Pennington 1999). The problem with CAPT is worsened by the fact that some of the newest technologies that are employed within these systems, like ASR, are not yet perfect. For instance, highly sophisticated error diagnosis by means of ASR still suffers from erroneous performance that results in confusing feedback (Menzel et al. 2000). These limitations can pose constraints on the design of CAPT – in particular on the design of the feedback-system. However, even when all precautions are taken, one will have to reckon with a certain number of errors.

The ultimate aim of our research is to determine to what extent feedback errors that are generated by a system can be tolerated, in the sense that they do not impede learning. Because of the crucial role of this factor in learning pronunciation, we believe that an investigation in this area would be extremely useful. The domain in which we will work is the acquisition of pronunciation in Dutch by adults with different language backgrounds. Pronunciation training, scoring, and feedback will be provided via a widely used multimedia comprehensive language course to which we will add an ASR module.

In this presentation, we report on the work that we have carried out so far and account for the choices we have made for our research. First, we analyse available literature on traditional pronunciation training in order to identify the basic pedagogical criteria that a system should ideally meet. Second, we provide a critical evaluation of those CAPT systems that more closely

fulfil those demands, with a view to establishing which pedagogical aims can be achieved with state-of-the-art technology. In doing so, we focus in particular on the issue of feedback. Third, we combine the information thus gathered to present our proposal for a realistic and pedagogically sound CAPT environment that will be employed in our research on erroneous feedback. Finally, we describe the methodological steps that we will follow and briefly report on the current status of our project.

2. L2 pronunciation: guidelines for optimal training

From an overview of the literature it becomes clear that little information is available on how pronunciation can best be taught. This is partly a consequence of the considerable variety in teaching contexts and learning aims, which makes it difficult to set hard-and-fast rules that can be applied universally, across different learning settings. This scarcity of indications can also be ascribed to a large extent to certain attitudes and beliefs about pronunciation that several researchers shared until recently. According to such views, accent-free pronunciation of the L2 was only a myth (Hill 1970, Scovel 1988), therefore it did not deserve as much attention as other linguistic skills; moreover, according to some, formally teaching L2 pronunciation was pointless or even counterproductive (Krashen 1981). However, recent studies have contradicted some of these beliefs and indicated that tailor-made training can improve a learner's pronunciation to such a point that – to human judges - s/he can sound indistinguishable from a native speaker (Flege 1999, Bongaerts 2001). A close examination of recent research can thus help us to identify some general guidelines on pronunciation training.

To begin with, students must be able to access large quantities of input, so that target models become available. Multiple-talker models seem to be particularly effective to improve perception of L2 novel contrasts as the inherent variability allows for induction of general phonetic categories (Logan et al. 1991). Mere exposure to the L2, on the other hand, does not appear to be a sufficient condition for pronunciation improvement, as is exemplified by long-term foreign residents who retain a strong accent and are hardly intelligible in the L2 (Morley 1991).

Specific training must be provided and students need above all to be given the opportunity to practise (Hendrik 1997). Special care should be taken to create meaningful, engaging and stress-free environments that encourage speech production even from the least talkative students and promote learning (Morley 1991, Hendrik 1997). This can be done by selecting varied material that accommodates different cognitive styles and that also allows self-monitoring and planning (Morley 1991, Murray 1999). Output is a necessary condition as it enables learners to compare their own production with the correct input (Swain 1985). In pronunciation, this is the first step leading to an understanding of one's pronunciation deviations.

Most of these errors can be attributed to interference phenomena from the L1 built-in phonological representations (Flege 1995). The L1 influence can be so overwhelming that simple comparison of input with output may not lead to the perception of the discrepancies between the learner's interlanguage and L2 standards (Flege 1995). Feedback must then come into play. Through the provision of feedback teachers can bring the students to focus on specific problems, which hopefully stimulates them to attempt self-improvement.

It goes without saying that teachers do not need to provide feedback on each of the student's mistakes: such a course of action would be discouraging for the student and extremely lengthy for the teachers themselves. Moreover, it is important to bear in mind the ultimate goal of pronunciation training: as most learners do not need to acquire a native-like pronunciation, efforts to eradicate small traces of foreign accent are often unnecessary. In this respect, it is fundamental for teachers and researchers alike to distinguish between two different dimensions of nonnative pronunciation: accentedness and intelligibility. These notions are related but fairly independent: a strong foreign accent does not always hinder intelligibility of speech and specific types of instruction do not necessarily lead to improvement of both these aspects (Derwing & Munro 1997).

In our study, we will aim at attainment of intelligibility of speech, following Abercrombie's claim that most language learners "need no more than a comfortably intelligible pronunciation [...] which can be understood with little or no conscious effort on the part of the listener" (1991:93). It follows that only those mispronunciations will be considered that are most detrimental to the intelligibility of the student' s utterances. Although clear indications on the relative gravity of the various pronunciation errors are still lacking, it appears that both segmental and supra-segmental factors are important. Segmental errors can sometimes preclude full intelligibility of speech (Derwing & Munro 1997). On the other hand, intonation is important too: it is "the glue that holds a message together" (Abercrombie 1991:64) as it helps listeners to process the segmental content. Furthermore, both levels are so tightly interwoven that, while they can be separated and measured instrumentally, in reality they influence each other, as the case of stress placement well illustrates.

2.1. Conclusions

On the basis of this brief synopsis, we can outline some recommendations for the design of effective pronunciation teaching and learning. Learning must take place in a stress-free environment in which students can be exposed to considerable and meaningful input and are stimulated to actively practise oral skills. Pertinent feedback should be provided individually and in real-time and should focus on those segmental and supra-segmental aspects which affect intelligibility most.

3. Available CAPT systems

CAPT systems seem to meet the requirements of pronunciation training and offer a number of advantages. First, they make it possible to address individual problems. Second, they allow students to train as long as they wish and in their own tempo. Third, by giving students a chance to train individually, these systems may lead to a reduction of foreign language classroom anxiety and thus indirectly favour learning (Young 1990). Finally, they offer the possibility to store student profiles in log-files, so that both the teacher and the student can monitor problems and improvements. On account of these advantages, there have been various attempts to develop CAPT systems.

Some of the systems that are currently available provide information on the way speech sounds should be produced or by explaining how the articulators should be positioned for the target sound. Despite the advantage they offer by displaying visual cues, which have been shown to improve speech perception and production (Massaro 1987), these systems are remarkably limited. They merely train receptive abilities and do not prompt the student to produce an utterance, while it is well known that speaking is crucial for improving pronunciation (Hendrik 1997).

Most recent systems, however, include record- and playback features: the learner produces speech that is recorded and can subsequently be evaluated by a teacher or used for comparison with a native utterance by the students themselves. The problem with the former type of systems is that it is up to the students to determine whether and how their own utterances differ from the native ones, while numerous studies have revealed that L2 learners often fail to perceive phonetic differences between their L1 and the L2 (Flege 1995). On the other hand, the latter type of systems, in which the recorded speech has to be evaluated by a teacher, suffer from the unfavourable teacher-student ratios, just like language classes in schools and universities.

Distance-learning systems allow circumventing this problem. These systems require the students to first practise and record themselves and then either up-load the audio-files to a web page or send the files via 'voice e-mail'. Licensed trainers listen to the files, evaluate and score them, and finally send them back to each student (Ferrier & Reid 2000, Wimba 2002). The limitation of these systems is that the feedback will be provided according to the evaluator's time and willingness.

Some other CAPT systems make use of tools (e.g. Pro-nunciation 2002, Lambacher 1999) that perform acoustic analyses of amplitude, intonation, duration and frequency of the student's speech and show the results on a spectrographic display. While the level of detail with this type of feedback can be very high, the effectiveness of these systems is also questionable, as students will have a hard time deciphering these displays and even expert phoneticians may find it difficult to extract the information needed to improve pronunciation. Conversely, systems with easy editing features, such as WinPitchLTL (Germain-Rutherford & Martin 2000), require the teacher to provide an explanation to accompany these displays, in order to make them easy-to-interpret. This time the problem is twofold: the student has to rely on the teacher for individual feedback, and the costs that this feedback-system implies are rather high, in terms of the time the teacher has to devote to learn acoustics and to provide such detailed feedback for each of the students' utterances.

In view of the problems mentioned so far, ASR technology seems to provide an optimal solution to pronunciation training. Systems that require constant support from a teacher or expert are neither cost- nor time-effective. The fully automatic systems mentioned above, on the other hand, only offer generic instruction that can be relevant for many different learners. But each learner is unique and ideally deserves undivided attention, therefore optimal training should envisage a one-to-one learner to tutor relationship. Systems incorporating ASR modules can provide this type of interaction, making it possible to detect individual errors and to provide immediate feedback. However, owing to the limitations of this technology, most of the systems available are far from ideal.

One way of providing immediate, though implicit, feedback on pronunciation, is used by systems that react, by means of graphic simulations, to a student's prompt (see *TracyTalk* by CPI and the *MILTS microworlds* described in Holland et al. 1999, Wachowicz & Scott 1999). If the command is correctly pronounced, the computer will recognize it and perform it. Even though very realistic, this type of feedback alone does not provide any metalinguistic information on the quality of the utterance.

For this reason, some systems also include or solely resort to a score of the students' utterance. The usefulness of automatic scoring is evident as this technology gives the learner immediate information on overall output quality. Besides, anecdotic evidence of positive student appreciation of global automatic pronunciation scoring has been reported (ISLE 1.4 1999). However, the difficulty lies in developing

computer measures that adequately reflect pronunciation quality. One criterion that has been used to assess the adequacy of machine pronunciation scores is that they should correlate strongly with pronunciation ratings assigned by human experts. Although this appears to be a necessary criterion, it is certainly not sufficient to guarantee machine pronunciation scores that constitute an appropriate basis for providing feedback on pronunciation. For example, various temporal measures of speech quality that can be calculated automatically appear to be strongly correlated with human ratings of pronunciation and fluency (Cucchiarini et al. 2000a, Franco et al. 2000). In general, measures indicating a higher speech rate are associated with higher pronunciation ratings. Because of the strong correlations with human ratings, these temporal machine scores appear to be suitable for pronunciation testing, but it would not be sensible to use them as a basis for providing feedback on pronunciation: telling students to speak faster is not likely to improve their pronunciation quality. *FreshTalk* exemplifies the sort of system in which nonnativeness measures such as temporal measures are used as a basis for providing feedback, and indeed, the feedback provided did not prove to be effective to improve the users' pronunciation skills (Precoda et al. 2000).

Some systems, like the *Talk to Me/Tell Me More* series by Auralog (Auralog 2002) display a score and an oscillogram of the student's utterance. An oscillogram of the model utterance is presented simultaneously to allow for comparison. However, as we already pointed out, oscillograms are hardly interpretable, thus the student is likely to make random attempts at correcting the presumed errors, which, instead of improving pronunciation, may have the effect of reinforcing bad habits (Eskenazi 1999). In order to be effective, feedback should be comprehensible in the first place. Many visual displays such as oscillograms and spectrograms may look very impressive, but there is little chance that they will provide useful information on the pronunciation errors the student made (Ehsani & Knodt 1998).

Kommissarchik and Kommissarchik (2000) have discussed the shortcomings of these forms of feedback and have developed a system for teaching American English prosody, *BetterAccentTutor*, in which comprehensible feedback is provided. Immediate, automatic audio-visual feedback is provided on intonation, stress and rhythm. Both the students' and the natives' patterns are displayed on the screen so that the students can compare them and notice the most relevant features they should match (Betteraccent 2002). This program, however, does not address segmental errors.

A serious attempt at diagnosing segmental errors and providing feedback on them has been made in the ISLE project (Menzel et al. 2000). This system targets German and Italian learners of English, and aims at providing feedback on pronunciation errors, focussing in particular on the word level, for which it checks mispronunciations of specific sounds and lexical-stress errors. The knowledge-based character of this system implies that this approach can only be adopted when the L1 background of the user is known, when the number of L1s is limited, and when knowledge on typical errors is available. The danger of such systems is that they are not able to detect individual intra-learner idiosyncrasies, which may also be detrimental to comprehension.

The system provides feedback by highlighting the locus of the error in the word. In addition, example words are shown on the screen, which contain, highlighted, the correct sound to imitate and the one corresponding to the mispronounced version. The student can also click on either word or on the single sound to hear them pronounced. While this feedback design seems satisfactory, the system yields poor performance results. The authors report that only 25% of the errors are detected by the system and that over 5% of correct phones are incorrectly classified as errors. As the authors comment, with such a performance "students will more frequently be given erroneous discouraging feedback than they will be given helpful diagnoses" (Menzel et al. 2000:54).

3.1. Conclusions

To summarize, this overview of available CAPT systems has identified a number of pros and cons, which should be taken into consideration when developing new prototypes. We have seen that systems that incorporate ASR technology offer the advantage that they evaluate the students' speech and provide feedback in real-time. However, when designing CAPT systems that make use of ASR technology, we will have to reckon with the limitations of this technology, which, among other things, imply that the speaker's utterance has to be predictable and that error diagnosis is only possible with a limited degree of detail. As to the type of feedback to be provided, it appears that, ideally, feedback should address both segmental and supra-segmental aspects of speech production. In addition, the form in which feedback is provided is very important: feedback should be pertinent and easy to interpret. Finally, although detailed diagnosis may be desirable, this is definitely not feasible with state-of-the-art ASR technology, because the performance levels attained are too poor. It therefore seems that we will have to settle for something which is a less ambitious, but that can guarantee correct feedback at least in the majority of the cases.

4. The PROO project

As we already stated, the main goal of the pronunciation training in our research is intelligibility of speech in Dutch as L2. Bearing in mind this goal, and following

the recommendations stemming from research on pronunciation and from our analysis of the pros and cons of available CAPT environments, we will deploy an ASR-based system that enables students to actively practise oral skills and receive scores and feedback on their mistakes. For this purpose we will use an ASR module that has previously been developed at our department, which is able to recognize and score nonnative speech (Cucchiarini et al. 2000b). This ASR module will be included in the Dutch language course *Nieuwe Buren* (New Neighbours, Nieuwe Buren 2002).

Pronunciation training will be done, just as is currently the case, partly by the teacher, partly by the students individually in sessions devoted to work on the computer, during which all the students' interactions will be stored on a log-file. The course requires the teacher to supervise these sessions so that help can be provided if necessary. The presence of the teacher should allow for a reduction of anxiety in 'technophobic' learners (Murray & Barnes 1998) and for provision of a certain degree of extrinsic motivation (Murray 1999).

Exercises will be designed so as to prompt the students to produce oral utterances that they will be able to compare with model utterances. Audio-visual material already developed for use in the course will ensure speaker variability in the oral input. The course material includes different real-life activities in which the student is exposed to authentic and meaningful language.

The selection of the errors to be addressed will be based on the following criteria: 1) frequency among learners of Dutch as L2, 2) persistence, 3) perceptual importance for native speakers, 4) reliable automatic detectability. This should ensure that no time is wasted on less important errors or on errors that simply disappear through exposure to the L2, and that the system does not suffer from excessive degradation in recognition and erroneous, confusing diagnosis. Automatic feedback will be given in real-time to prevent serious mistakes from becoming hard-to-remove habits. It will focus on segmental and supra-segmental aspects ranging from word-stress, sentence-accent, and temporal and spectral quality of speech sounds. Automatic feedback on the students' responses will be given at two levels: a score on overall comprehensibility will be given, followed by a description of the error - mispronounced phones or syllables will be visually highlighted, and the students will have the possibility to compare their own output with the correct form. In order not to discourage the students, we will set a maximum number of errors to be pinpointed per utterance.

4.1. Procedure

The system will first be tested on a group of experts consisting of phoneticians and speech therapists. Once the system has shown good functionality, it will be tested on an experimental group. Pre-tests will be run on the experimental group and on a control group who will use the original version of *Nieuwe Buren* without immediate feedback. After the training, the pronunciation performance of the experimental group will be measured against that of the control group. This evaluation will tell us whether automatic immediate feedback does indeed lead to global improvement in L2 pronunciation. Just as human tutors sometimes make mistakes, we can already predict that the system will at times generate errors due to limitations in the state-of-the-art technology. Therefore we will perform a more detailed analysis of individual results within the experimental group. This will provide better insight into the specific effects of correct and erroneous feedback. Finally, students and teachers will be required to complete a questionnaire meant to evaluate the feedback-system's user-friendliness, comprehensibility and adequacy (the control group will, by contrast, report on learning without real-time feedback). The experiment and the tests will subsequently be repeated with an improved version of the system.

5. Conclusions

In this paper, we have first examined available literature on traditional pronunciation training in order to identify some basic pedagogical criteria. We then considered various CAPT systems that are now available to determine whether they fulfil these criteria and which pedagogical aims can be achieved with state-of-the-art technology. We subsequently combined the information obtained from these two lines of research and concluded that various devices are often used without an underlying pedagogical criterion, simply to make a fancy-looking product. To improve on this, we suggest that developers first focus on the learner's needs and accordingly select functionalities that meet those needs. Our overview of available systems has revealed that despite limitations in the technology, it is possible to develop CAPT environments that are realistic and pedagogically sound at the same time.

In our project we will develop one such system on the basis of the guidelines identified. This system will then be employed to investigate the effect of erroneous computer-generated feedback on learning.

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7. References

Abercrombie, D. (1991[1956]) Teaching pronunciation, in A. Brown (ed.), *Teaching English Pronunciation: A Book of readings*, Routledge: London, 87-95.

Auralog (2002) Auralog, innovations for language learning, http://www.auralog.com. Last consulted 27/02/2002.

Betteraccent (2002) Our methodology, http://www.betteraccent.com/baapproach.htm. Last consulted 25/02/2002.

Bongaerts, T. (2001) Age-related differences in the acquisition of L2 pronunciation: The Critical Period Hypothesis revisited, *EUROSLA workshop on the age factor in SLA*, University of Paderborn, Germany.

Cucchiarini, C., Strik, H., Boves, L. (2000a) Different aspects of pronunciation quality ratings and their relation to scores produced by speech recognition algorithms, *Speech Communication* **30**, 109-119.

Cucchiarini, C., Strik, H., Boves, L. (2000b) Quantitative assessment of second language learners' fluency by means of automatic speech recognition technology, *Journal of the Acoustical Society of America* **107**, 989-999.

Derwing, T.M., Munro, M.J. (1997) Accent, intelligibility, and comprehensibility, *Studies in Second Language Acquisition* **20**, 1-16.

Ehsani, F., Knodt, E. (1998) Speech technology in computer-aided learning: Strengths and limitations of a new CALL paradigm, *Language Learning and Technology* **2**, 45-60. Available online at http://llt.msu.edu/vol2num1/article3 /index.html. Last consulted 27/02/2002.

Eskenazi, M. (1999) Using automatic speech processing for foreign language pronunciation tutoring: Some issues and a prototype, *Language Learning and Technology* **2**, 62-76. Available online at http://llt.msu.edu/vol2num2/article3/index.html. Last consulted 27/02/2002.

Ferrier, L. Reid, L. (2000) Accent modification training in *The Internet Way®*, *Proceedings of InSTIL 2000,* Dundee, Scotland*,* 69-72.

Flege, J.E. (1995) Second-language speech learning: Findings and problems, in Strange, W. (ed.), *Speech Perception and Linguistic Experience: Theoretical and Methodological Issues,* Timonium, MD: York Press, 233-273.

Flege, J. E. (1999) Age of learning and second language speech, in Birdsong, D. (ed.) *Second Language Acquisition and the Critical Period Hypothesis*, Mahwah, NJ: Lawrence Erlbaum Associates, 101-131.

Franco, H., Neumeyer, L., Digalakis, V., Ronen, O. (2000) Combination of machine scores for automatic grading of pronunciation quality, *Speech Communication* **30**, 121-130.

Germain-Rutherford, A., Martin, P. (2000) Présentation d'un logiciel de visualisation pour l'apprentissage de l'oral en langue seconde, *ALSIC* **3**, 61-76. Available online at http://alsic.u-strasbg.fr/Menus/frameder.htm. Last consulted 25/02/2002.

Hendrik, H. (1997) Keep them talking! A project for improving students' L2 pronunciation, *System* **25**, 545-560.

Hill, J. (1970) Foreign accents, language acquisition, and cerebral dominance revisited, *Language Learning* **20**, 237-248.

Holland, V.M., Kaplan, J.D., and Sabol, M.A. (1999) Preliminary tests of language learning in a speech-interactive graphics microworld, *CALICO Journal* **16**, 339-359.

ISLE 1.4 (1999) Pronunciation training: Requirements and solutions, *ISLE Deliverable* 1.4. Available online at http://nats-www.informatik.uni-hamburg.de/~isle/public/D14/D14.html. Last consulted 27/02/2002.

Kommissarchik, J., Komissarchik, E. (2000) Better Accent Tutor – Analysis and visualization of speech prosody, *Proceedings of InSTIL 2000,*Dundee, Scotland, 86-89.

Krashen, S.D. (1981) *Second language Acquisition and Second Language Learning,* Oxford: Pergamon Press.

Lambacher, S. (1999) A CALL tool for improving second language acquisition of English consonants by Japanese learners, *Computer Assisted Language Learning* **12**, 137-156.

Logan, J.S., Lively, S.E., Pisoni, D.B. (1991) Training Japanese listeners to identify English /r/ and /l/ III: Long-term retention of new phonetic categories*, Journal of the Acoustical Society of America* **89**, 874-886.

Massaro, D.W. (1987) *Speech Perception by Ear and Eye: A Paradigm for Psychological Enquiry,* Hillsdale, NJ: Lawrence Erlbaum.

Menzel, W., Herron, D., Bonaventura, P., Morton, R. (2000) Automatic detection and correction of non-native English pronunciations, *Proceedings of InSTIL 2000,* Dundee, Scotland, 49-56.

Morley, J. (1991) The pronunciation component in teaching English to speakers of other languages, *TESOL Quarterly* **25**, 481-519.

Murray, G.L. (1999) Autonomy in language learning in a simulated environment, *System* **27**, 295-308.

Murray, L., Barnes, A. (1998) Beyond the 'wow' factor – evaluating multimedia language learning software from a pedagogical point of view, *System* **26**, 249-259.

Nieuwe Buren (2002) Nieuwe Buren, http://www.nieuweburen.nl. Last consulted 26/02/2002.

Pennington, M.C. (1999) Computer-aided pronunciation pedagogy: Promise, limitations, directions, *Computer Assisted Language Learning* **12**, 427-440.

Precoda, K., Halverson, C.A., Franco, H. (2000) Effects of speech recognition-based pronunciation feedback on second-language pronunciation ability, *Proceedings of InSTIL 2000,* Dundee, Scotland, 102-105.

Pro-nunciation (2002) Products, http://users.zipworld.com.au/~pronunce/products.htm. Last consulted 26/02/2002.

Scovel, T. (1988) *A Time to Speak: A Psycholinguistic Inquiry into the Critical Period for Human Speech*, Cambridge: Newbury House.

Swain, M. (1985) Communicative competence: some roles of comprehensible input and comprehensible output in its development, in Gass, M.A., Madden, C.G. (eds.) *Input in*

Second Language Acquisition. Rowley MA: Newbury House, 235-253.
Wachowicz, K., Scott, B. (1999) Software that listens: It's not a question of whether, it's a question of how, *CALICO Journal* **16**, 253-276.
Wimba (2002) Wimba - Products http://www.wimba.com/products.php. Last consulted 30/05/2002.
Young, D.J. (1990) An investigation of students' perspectives on anxiety and speaking, *Foreign Language Annals,* **23**, 539-553.