

MIMIC - vootiue demonstration program for parents of cochlear implanted children

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Abstract

To illustrate to parents the problems their implanted children are facing, to demonstrate their solutions, to explain the differences between the implanted patients and the different speed of mastering speech perception, equalization of results as a result of teaching (rehabilitation) we created and patented the demonstration program "MIMIC" (Petrov 2006). There are parallels between speech recognition by users of cochlear implants (CI) and recognition of comb filtered speech by normal hearing persons (Petrov and Pisareva 2011). MIMIC is based on these parallels. This demonstration is carried out on the own ear of the participant, i.e. vootiue (vo-in, oto - ear). In Russian-воотию (vo-in, ото-ear). To a certain extent, this program is a model of perception of "implanted" language. MIMIC gives parents an inside look at the problems of their implanted children. MIMIC doesn't depend on the type of an implant. This article describes the procedure for conducting a demonstration, explaining the results obtained from the patient, and answering typical questions. Our article aims to demonstrate some of the problems faced by cochlear implanted patients and their solution, but does not aim to provide an accurate simulation of their auditory percept.

Keywords: Speech perception, comb filtering, spectral deprivation, vootiue, auditory teaching

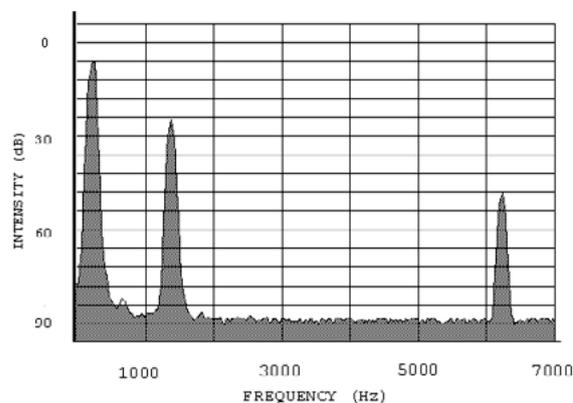
Methodology

Production of comb filtered speech stimuli

The original test material is a standard 4 lists of words (30 words per list) as used in routine speech audiometry. Three lists are used in the demo, one for setting a comfortable loudness level. The original speech recording is comb filtered (Petrov 1999, 1) to retain only 3 spectral bands of 50 Hz width spaced over the range 200-6250 Hz. 97.5% of speech spectrum is deleted so we use spectrally deprived speech. The central frequencies of these test bands are selected in such a way to correspond to basilar membrane locations equally spaced at 10.4 mm distance from each other (Hartmann 1996) - 3-channel implant.

The spectrum of used words is shown in Figure 1.

Figure 1: Spectrogram of comb filtered words analyzed by the "Adobe Audition" program



Sequence of demonstration

First test

The participant is required to listen to the comb filtered word lists and repeat each recognized word. Two lists (i.e. 60 words in total) are used. The words are presented with a 5-second interval between them. If the word is identified correctly the participant is informed by the experimenter by raising his hand. For support and approval. Correct answers are marked in a word lists.

At the end of the first test, audiologist can listen to some doubts-concerns of the participant. Calm him down. We say, "Don't worry, this isn't the end of the demo" and move on to the teaching.

Teaching

During the teaching each word is first pronounced clearly in live voice and then the same comb filtered word is presented and repeated several times (if necessary) until the participant agrees that he hears the same word.

After the teaching stage you can listen to the description of the sensations of the subject and repeat that further he only needs to listen to the words and recognize them.

Second test

After completing the teaching stage the same 60 words are presented again. The participant is asked to repeat the word when possible. If the word is identified correctly the participant is informed by the experimenter by raising his hand. Correct answers are marked in a word lists.

Third test

Immediately after the end of 60 words, a new list of 30 comb filtered words is then presented to the participant. The participant is asked to repeat the word when possible. Correct answers are marked in a word lists.

At the end of the session, the experimenter calculates the results of all tests and begins to discuss and explain them. The total duration of testing and teaching is about 30 minutes.

Discussion of results with a MIMIC participant

In order to discuss their results with parents (the main part of participants), it is necessary to have individual results of at least several patients to start working. And the average values of the three tests of this group. We also started from scratch. In our work, we use results of recognition scores for 38 normally hearing participants (Table 1) (Petrov and Pisareva 2011). And in total, more than 100 subjects participated in the MIMIC.

Table 1: Mean intelligibility scores and range of results (%) for first, second (familiar words material) and third (new words material) tests.

	1st test	2nd test	3rd test
Mean	16.5±10.2	57.2±9.0	51.4±10.2
Range	0-37	45-73	37-70

The first thing that can be seen from this table is a clear increase in the recognition of words in the second test compared to the first ($p<0.01$), absence of differences between the results of the second and third tests ($p<0.05$) and a large spread of individual results in all tests.

Discussion

We show to the participant his results and discuss them with him.

First test

Here is your result on the first listen - NN%. We ask: "Do you remember what it felt like on the first test?" We listen to them. Next, we show the range of group results for the first test in Table 1.

N. B. The spread of the results of the first test is 0-37% - an illustration of the different abilities of participants to tune in to understand a new picture of words. The variability of results on the first test is analogous to speech recognition differences among newly implanted patients.

Teaching

During the teaching many participants are surprised that they recognize words that they did not understand in the first test. Some recognized it from the first audition and exclaimed in surprise: "Exactly it!" During the teaching, participants change their attitude to the sound of the processed speech.

N. B. The recognition of a processed words when learning from the second or third repetition is an illustration of the different abilities of participants to learn to understand new impoverished words.

Second test

You remember your feelings during the first test, were surprised by the understanding of words during teaching, and here is your result after teaching. Your second test score is MM% - several times higher than the first test score - a clear improvement in word intelligibility after such a short training. Look at the results of the group in Table 1. There is significant difference between the first and second (following teaching) test results on a paired t-test ($p < 0.01$). A significant difference of the results of the second test compared to the first is a clear illustration that CI patients can learn to understand impoverished speech.

N.B. The spread of the results of the second test - 45-73% is an illustration of the different abilities of the participants to tune in to understand a new picture of words. The variability of results of the second test is analogous to speech recognition differences among newly implanted patients.

So. After learning, you understood MM% of the words, but look at what you heard.

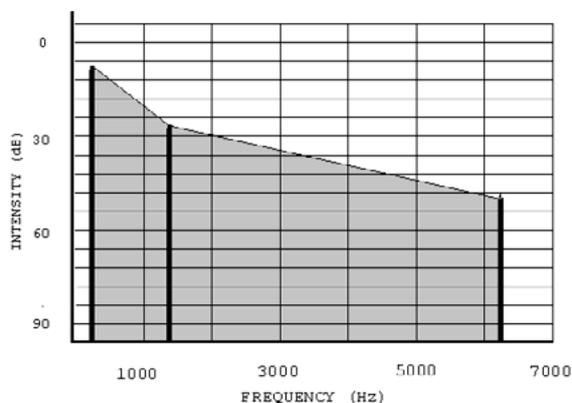
For greater clarity, we schematically presented part of the spectrum of the words from the lower border of the first band (200 Hz) to the upper border of the third band (6250 Hz) (Fig. 2).

In real life, you perceive all the frequencies-6050 tones-in this frequency range, and now you have heard 3 bands of 50 Hz, i.e. 150 tones, which are highlighted in black. Is your result of intelligibility impressive? It is hard to believe that by getting only 1/40 (!) part of the speech information (150/6050), you can understand more than 50% of the words after a short teaching. But you heard it vootue

— in your own ear. The large improvement in comb filtered words understanding after short teaching demonstrates to the participants that they developed some ability to recognize very spectrally deprived speech.

It should be noted that the full spectrum of speech is wider than the band used in our work, and in reality you have heard even less than 2.5% of the speech information.

Figure 2: Schematic spectrum of speech in range of 200-6250 Hz (grey and black), from which you heard only three bands of 50 Hz width (black).



Third test

In the second test, you were tested with the same words that you were taught. You can assume that you have memorized them. And here is your result of the intelligibility of the comb filtered words that you heard for the first time - PP%. This result is close to the result obtained after teaching - in the second test. It means that you did not simply remember some of the test words but developed new skill of recognition of the spectrally deprived speech, which contain only 1/40 (!) part of the speech information.

Let us look at the results of the group. The calculations showed that there are no significant differences between the results of the second and third tests. The absence of differences between the results of the second and third tests of the group is an illustration of the opportunity to learn to understand the new picture of spectrally deprived speech, which is missing 97.5%(!)of speech information. Of course, all of you with normal hearing know all the words they have heard, but to recog-

nize them by 1/40 part of the speech spectrum is amazing for you.

All participants were impressed by their scores obtained in the third test with unknown test material. Developing this new skill through a single short teaching session enabled the majority of the participants to recognize more than 50% of transformed words. It is interesting to note that when developing MIMIC at first time we did not use the third test. We entered it out of curiosity and were surprised by the result after such a short teaching. Participants were too. The third test demonstrates to the participants that they have developed a new skill to recognize spectrally deprived speech.

Key results and answers to some questions from parents

Using the results obtained from participants, we can reasonably answer the most common questions of parents.

Parents during the first session of fittings communicate with each other, observe the differences between their children and want to understand the reason why their child's results are lower. It is clear that they do not ask why their results are better. Participating in MIMIC helps parents to understand: **How to explain the differences between our children?** Of course, provided that the fittings are of the same quality. We answer: "All you have normal hearing and understand normal speech without any difficulty, but look at the spread of individual results of all subjects in recognition of spectrally deprived speech (Table 1) in all three tests. It is logical that similar differences in understanding "implanted language" might be expected in CI users. Differences between normally hearing subjects in understanding spectrally deprived speech explain different abilities of CI patients to understand speech transformed by an implant". The differences between the subjects with normal hearing in the results of perception and the speed of learning to understand impoverished speech indicate the presence of similar differences between their children.

Participating in MIMIC helps parents to understand: **How can implanted patients understand speech?** During the explanation,

we remind the participants of their impression of attempting to understand the spectrally deprived speech in the first test. Speech processed by a CI provides more usable speech information. Then we point out again that they didn't just memorize the words when teaching, but learned to understand the new picture of comb filtered speech thanks to the short(!) teaching. It should be especially emphasized that the subjects heard words in which 97.5 percent of the speech spectrum (even more) is absent. There are similarities between speech perception of CI users and normal hearing subjects when listening to spectrally deprived speech (Petrov and Pisareva 2011). Parents better understand the initially unclear auditory experience of CI users and how this can be improved through teaching. On their experience of MIMIC parents clearly understand the importance of learning the perception of new («implanted») language, i.e. necessity of auditory-speech rehabilitation of CI users.

In addition to simply proving the positive impact of learning on the development of understanding of new very impoverished speech, the MIMIC demonstrates to participants that learning equalizes the results of mastering the understanding of new impoverished speech – from more than tenfold differences of results in the first test to twice in the second and third. Successful learning to understand transformed speech by parents is a clear illustration of CI patients' speech perception, where they also learn to understand speech significantly transformed in comparison to normal speech (see Instruction below- Appendix 2). This is the next parallel between CI and MIMIC: In both cases a subjects are able to understand impoverished speech due to the redundancy inherent in the full spectrum speech signal.

We can assume another "side" effect of the MIMIC. We believe that parents are beginning to better understand what means comfortable loudness of speech material. Previously, most of them did not take part in such studies, and they will transfer their new understanding when setting their comfortable loudness level to understanding the child's comfortable program. To sharpen this understanding, we need to ask: How did you like the loudness in terms of intelligibility?

They will think about it and connect the comfortable loudness and intelligibility of speech in their children.

Judging by the written (Appendix 1) and heard reviews of the MIMIC participants, all of them — parents, teachers, audiologists—were grateful and themselves noted a clear improvement in understanding the problems of their children and the features of teaching them. And in general the parents developed a far better understanding of the CI problem and their questions became more specific ones. The participating teachers asked to implement this program MIMIC to all the rehabilitation centers.

MIMIC is a vivid demonstration of the capabilities of the human brain, and, of course, the ability of the brain of CI patients to master the unique “implanted” language. And the implementation of these opportunities is the clear success of implanted children in mastering speech recognition — up to 100%. MIMIC is a testament to this.

Appendix 1. Quotes from participant' evaluations of DEMO MIMIC

Generally, typical comments made by parents after the end of the MIMIC included (1) “It is very surprising to see how it is possible to develop skill to recognize spectrally deprived words (with 97.5% of the spectrum missing)”, (2) “I can now begin to understand the problems of my child”, (3) “It is important that this program has to be shown to all parents of implanted children”.

I asked a few participants of MIMIC to write reviews. After unanimous approval of MIMIC by 14 participants (8 teachers and 6 mothers) I stopped collecting of written comments. All reviews are positive up to rave estimations. Only the praises of the MIMIC. Quotes from the full reviews are below. All the other participants of MIMIC (more than 100) thanked me with words.

8 opinions of speech therapists:

- A. It's just brilliant! With respect
- B. Grand, clear, accessible, visually impressive

- C. Great program. It should be embedded in each Centre of audiology.
- D. MIMIC gives you the opportunity to give hope to parents. And to inspire.
- E. Be sure to demonstrate it to all mothers, it should give them confidence
- F. Very useful and valuable technique. CI relatives, teachers, doctors working with CI must participate in this program. Spasi-Bo! (Th-a-nKs)
- G. Owing to this DEMO-program I was able to “vootiue” get in touch with the hearing problems of children and adults with CI.
- H. The program must be demonstrated to all CI mothers. This will instill confidence in them.

6 opinions of CI-mothers

- A. All parents of CI-children just need to participate in this DEMO-program MIMIC
 - B. I'm glad I agreed to participate in MIMIC. Got a lot of useful information
 - C. I have to say that the program is brilliant.
 - D. Thanks for the program! Will remember for a lifetime! It (MIMIC) brought me closer to the problems of the child and gave a lot to understand!
 - E. MIMIC is unique Program!
 - F. There is opinion of mother and speech therapist simultaneously:
 - G. The importance of MIMIC lies in:
 - H. Accessibility of demonstration
 - I. The ability to understand the problem of development of CI-speech
 - J. To understand the importance of education
- Importantly, MIMIC is performed vootiue, i.e. on a “live ear”.

Appendix 2. Instruction for participants

Specialists and CI relatives want to understand what CI patients hear and how they learn to understand speech.

The transformation of speech in the implant briefly: At each moment of time the speech signal has a certain spectrum. This instantaneous (momentary) spectrum after

transformation in the implant is converted into a certain number of electrical pulses. These impulses directly stimulate the auditory nerve, and each impulse causes a auditory sensations of different frequency bands. Consequently, the implanted patient perceives the instantaneous speech spectrum as a sensation of a limited number of frequency bands. And speech in time as a change of the pictures of the instantaneous spectrum. The change of the instantaneous frequency spectrum is 700-1500 times per second. It is obvious that the normal speech spectrum is transformed and changes significantly, but - this is important - the new speech spectrum retains speech characteristics.

A clear physiological explanation of auditory perception of implanted patients and their speech comprehension problems is impossible for naive parents. The explanation requires starting with the basics of acoustics and physiology, which is hardly possible. Since it is difficult to explain with words, we need to demonstrate this by ear - vootiue (vo-in, oto-ear) - in the parent's own ear. By analogy with voochiue (vo-in, ochi-eyes).

For the purpose of this demonstration, we developed the MIMIC program. Previously, speech was significantly transformed (by analogy with the spectral changes of CI). The presentation of such a speech signal allows to demonstrate some aspects of perception and development of speech understanding of implanted patients. This program is not a demonstration of hearing of CI-patients, the program is an illustration of some similar problems with auditory perception of CI-patients and demonstration of their solutions for normal hearing subjects.

MIMIC is executed on the comfort loudness level which is not changed during the demonstration.

The first step is testing. On the monitor you will see a picture-bursts of words. Tell me how you identify these words. At first it is difficult to understand the words - do not give up, do not worry - analyze, do not delay. But take your time - the time to analyze is the empty interval between bursts of words. The speed of the presentation is one word per 5 seconds. If your answer is correct, I'll let you know, raising my hand.

The second step is teaching. I will tell you what word you'll hear. If you have identified it (clearly correlated with a known audible word), then tell me about it: either "YES" or "IT" or repeat the word. Or else, let me know you hear that word. If you do not fully agree, this transformed word will be repeated 2-3-4 times.

The third step is to retest the same words. And immediately after this testing

The last step - control. The first view of the new word list.

Participants! Turn off phone. All the attention on the survey. Do not be distracted by comparisons, reflections, considerations. Do not attempt to pass your results to your child during the MIMIC. All conversations at the end. Just listen, analyze, learn and repeat. Discussion, reasoning, considerations, comments, suggestions and explanations - all this at the end of the MIMIC.

The program lasts less than 30 minutes without talking-explanation.

We emphasize that CI patients hear differently, but their perceptual problems and their solutions are similar to your problems during MIMIC. N.B. CI patients get more information than you will get now.

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