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THE EFFECTIVENESS OF REHABILITATION BASED ON AN ORIGINAL COMPUTER PROGRAM: CASE STUDY OF A PATIENT WITH KINAESTHETIC APHASIA

Background: This article is about the rehabilitation of a patient with kinaesthetic aphasia based on an original computer program. The program facilitates the practice of correct kinaesthetic responses in patients with impaired sensation of the configuration of the various elements of the articulation apparatus.
Case description: The study was conducted on JB, a male patient with kinaesthetic aphasia following left hemisphere apoplexy. The computer-assisted therapy began in February 2006 and lasted until the end of June 2006. The article provides a detailed account of the changes in the patient's functioning resulting from the speech therapy conducted in the year 2006, and presents the results of the speech examination conducted after 33 months since its completion. The second study was performed in order to evaluate the lasting effect of the therapy.
Conclusions: The results of this study have demonstrated the effectiveness of speech therapy using an original computer program for the rehabilitation of patients with kinaesthetic aphasia.
Key words: aphasia, rehabilitation, computer-based therapy

Introduction

For several decades technological progress has greatly affected the organization of neuropsychological diagnostics and rehabilitation. The first promising reports on the feasibility of using computers in the therapy of patients with brain damage have encouraged neuropsychologists to find out whether using a computer would improve the effectiveness of rehabilitation, intensify practice and make it more attractive (e.g. Crerar, Ellis, 1995; Doesborgh, 2004; Katz, Ross, 2004; Loverso, Prescott, Selinger, 1992; Robertson, 1990).

At first, neuropsychologists wanted to know whether popular computer games could be of any use in the improvement of memory, reaction time, divisibility of attention or visual scanning. Although their findings suggested that selected cog-

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nitive functions did indeed improve, their optimism was premature because the gains did not transfer to unpractised tasks. The next step towards implementation of computers in the cognitive rehabilitation of patients with brain damage was to test educational programs. The programs were not adapted to neurological patients, however, and therefore it was not possible to rehabilitate them successfully using these programs. The first computer programs specifically designed to rehabilitate cognitive impairment in patients with brain lesions began to emerge in the late nineteen-seventies. One of them was *Driving School*, a program facilitating relearning of the highway code and practicing swift reaction. The purpose of these programs was to rehabilitate lost cognitive functions which are essential in everyday life such as memory, attention, speech or problem solving. Some of the computer programs acted as prostheses for lost competencies. For example, they were wired to remind patients to carry out planned activities or to help them communicate with their environment thanks to inbuilt speech synthesizers (Lynch, 2002).

Modern computer programs are designed to improve such daily activities as name retrieval, face recognition, shopping, planning and execution of complex tasks and to rehabilitate the following functions: planning, language competence, divisibility of attention, procedural memory, verbal memory, topological memory, decision-making, counting, reading, spatial orientation, word memorization, retrieval from short-term memory, reaction speed, mental rotation, articulation, and vocalization. Some computer programs also provide patients with helpful cues to ease their executive functions (Lynch, 2002).

Computer programs may be successfully applied in the rehabilitation of neurological patients if they provide new forms of stimulation which are inaccessible during traditional forms of therapy. Patients like to practice with the help of computer programs because their attractive graphics are an interesting change from traditional methods of rehabilitation and they enable the simultaneous stimulation of various modalities, for example sight, hearing and touch. Computer programs also help to enrich rehabilitation programs with additional stimuli, for example manipulation of the length of stimulus exposure, the number of variables, introduction of additional cues. This is not possible with conventional methods. Computer-assisted rehabilitation allows patients to engage in most tasks independently. This increases their sense of competence and hence their motivation to continue the tiresome exercises. It also reduces the stress induced by the therapist who can have a dispiriting effect in the first stage of rehabilitation. Another positive outcome which has been observed in patients participating in computer-assisted rehabilitation is increased self-awareness of their dysfunction. In everyday clinical practice it is difficult to provide several hours of rehabilitation to patients with brain damage and therefore inclusion of computerized rehabilitation exercises may be a good opportunity for many patients to participate in more intensive neuropsychological rehabilitation. Also, computer-generated stimulation increases the chances of focused activation of functions which have remained intact despite the injury.

Of course when rehabilitating the patient clinicians must not forget that computer programs cannot replace the psychologist because, in addition to conducting a comprehensive diagnosis and therapy, it is their job to establish a warm relationship with the patient based on understanding, concern, kindness and partnership. Good rapport with the patient is the foundation on which effective rehabilitation rests (Pąchalska, 1999).

Further work is needed to successfully implement computer programs for neuropsychological rehabilitation. One needs to be critical, however, and must not expect that inclusion of computers in the rehabilitation program will substitute contact with the neuropsychologist and traditional therapy. Many patients need more than just cognitive rehabilitation, they need professional individual or family therapy (Seniów, 2003).

Computer programs for the rehabilitation of patients with brain damage certainly carry the promise of intensifying traditional exercise packages and making practicing more attractive.

Case study

The enthusiastic reports of effective application of computer techniques in aphasiology encouraged the present author to develop a computer program for the rehabilitation of patients with kinaesthetic aphasia. Jacek Grunt-Mejer, a student at the Inter-Faculty Individual Studies in Mathematics and Natural Sciences, University of Warsaw, developed the software for this program.

Kinaesthetic aphasia involves an impaired sense of configuration of the various elements of the vocal apparatus following lesions in the left anterior parietal region. Patients with this impairment lose the "articulatory schemata", of phonemes and words which is manifested by difficulty in finding the articulatory positions appropriate for pronouncing different phonemes, confusing phonemes, that are similar in articulation, e.g., "1", "n", "t", "d", and "s". Analogous difficulties emerge in written speech whereas comprehension of oral speech is usually normal (Herzyk, 2005).

Traditional rehabilitation of kinaesthetic aphasia is based on the model developed by Alexander Luria (Nowakowska, 1978). The goal of rehabilitation is to reinstate the correct positioning of the articulation organs when uttering sounds, syllables or words. The most important appliance for this method is a mirror. Patients observe the various parts of the articulation apparatus in the mirror and also consult a diagram showing where the practiced sounds are articulated. During this traditional rehabilitation patients observe the position of the articulation apparatus as the therapist pronounces different sounds and at the same time they observe their own lips and tongue in the mirror. When teaching to pronounce sounds whose pronunciation cannot be directly observed, the therapist uses a diagram to show the patient exactly where the sound is articulated. The practice of sound pronunciation should be accompanied by exercises whose purpose is to improve oral praxis, e.g., patients are requested to open and close their mouths, smack their lips, pretend to blew out a candle, whistle, etc. At first, they practice the different sounds one by one, then in syllables. In the final phase of therapy, patients learn to read words which have many syllables. Each attempt to pronounce a sound, syllable or word should be accompanied by an appropriate graphic model and feedback on the correctness or incorrectness of the performance. The ultimate goal of therapy is to internalize

One of the obvious limits of the method presented above is its monotony and the fact that patients cannot simultaneously monitor the different elements of the therapist's articulation apparatus during model pronunciation of the practiced sounds, the graphic image presenting the position of the tongue, and the position of the different elements of their own articulation apparatus when pronouncing words independently.

The shortcomings of the traditional method of rehabilitation of kinaesthetic aphasia have inspired researchers to try to improve the method by applying a new tool, i.e., the computer. Use of a computer during the kinaesthetic aphasia therapy might help to generate forms of stimulation which cannot be produced when using traditional methods of rehabilitation of this type of language deficits. Computer programs are sufficiently refined to enable simultaneous, multichannel stimulation and they help patients to memorize the information they need to improve their language competencies.

Objective

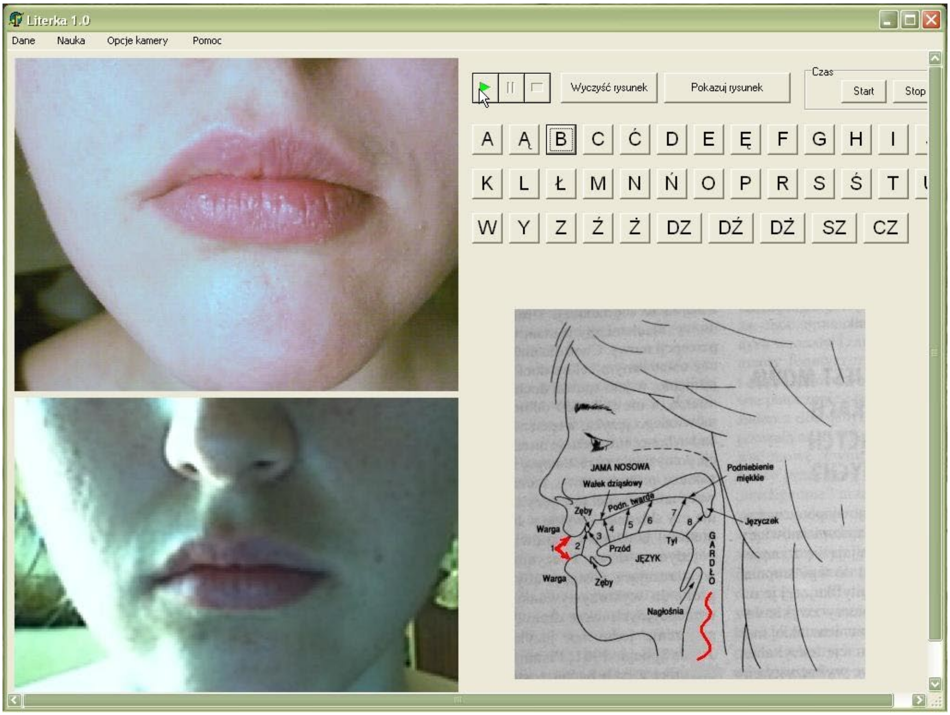
The objective of this study was to test the applicability of a computer program for the perfection of kinaesthetic reactions and to check whether the therapeutic outcomes would generalize to unpractised tasks. This was a pilot study and since it was based on a case study it should be treated as a preliminary report on the program's utility.

The instrument

The new computer program was designed to assist in the reconstruction of correct kinaesthetic responses in patients with kinaesthetic aphasia (according to Luria's classification system) whose principle defect involves impaired sensation of the position of elements of the articulation apparatus.

The tested model of computerized rehabilitation is rooted in the theoretical framework underlying traditional forms of therapy of aphasia developed by the behaviour modification school and the function reorganization school and is an attempt to combine the two approaches (Łojek-Osiejuk: in Balejko, 2003). As in the behavioral paradigm, the present approach uses modelling to develop specific verbal behaviors. This involves presenting the patient with an auditory model and a visual model of the practised sounds, syllables and words. Each correct response is positively reinforced with feedback about the success. According to the functional systems theory on which the function reorganization school

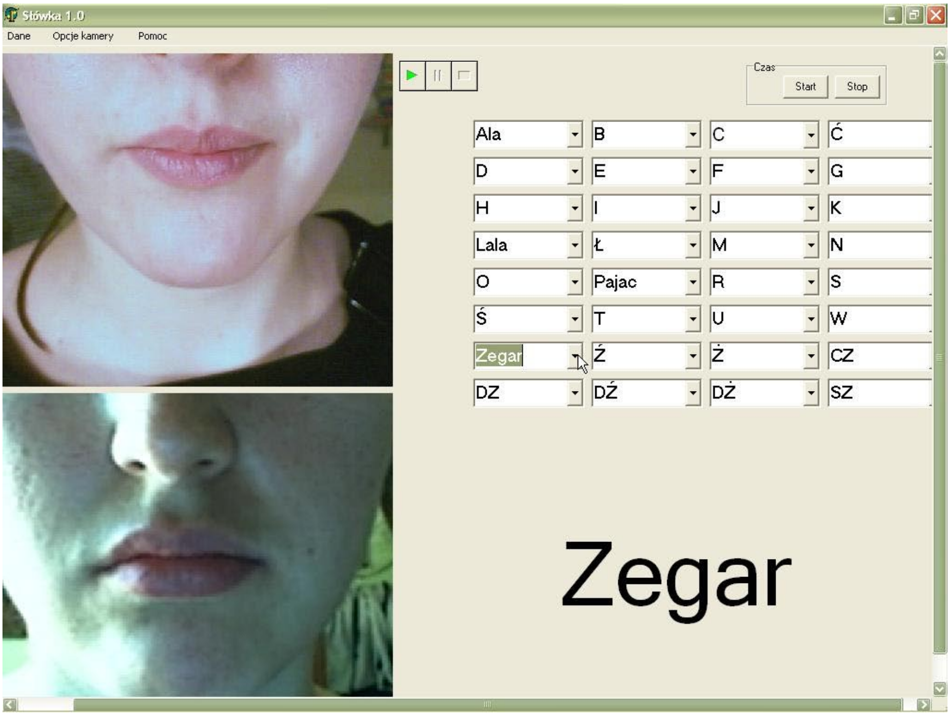
Figure 1. A photograph of the computer program interface



is based when testing the computer rehabilitation method, two functions, the ability to position the lips and tongue spontaneously when pronouncing sounds, are trained until they are once again automatic. The trained functional system is a different system from the original one, however. The computer rehabilitation involves presenting the patient with an aural and visual model of the practised sounds and words. As he or she utters the different sounds or words, the patient watches a recording of the correct lip and tongue positions on the computer screen and at the same time listens to correctly pronounced sounds. As we can see in Figure 1, while the patient practices the pronunciation of sounds, a diagram is displayed on the computer screen showing the majority of organs participating in the speech production. Red arrows indicate the points of articulation of the appropriate consonants. In the case of voiced consonants a red wave symbolizing voice appears in the location of the larynx.

This additional information is given so as to help the patient to memorize the correct position of the articulation organs during the pronunciation of various sounds. As the sounds or words are presented, the patient views the position of his or her own lips and tongue on the computer screen thanks to projection of the image from the Internet camera. This option replaces the mirror used in traditional

Figure 2. A photograph of the computer interface during the practice of word pronunciation



therapy. The patient is able to simultaneously monitor the position of her own articulation apparatus and the elements of the lector's articulation apparatus. The program also has additional options, START, PAUSE, STOP, so the patient can interrupt or repeat the presentation at any moment. The model is presented first and then the patient is requested to repeat. The speech therapist times the performance with a timer. Two elements are scored: correctness of repetition and reaction time. All the scores are registered in the software memory. The rehabilitation program has two different levels of difficulty. Analogous to the traditional method, training at the first level involves pronunciation of all the letters of the Polish alphabet. Training at the second level involves practicing the pronunciation of 282 words. The words are presented in order of increasing difficulty, from one-syllable words to multi-syllable ones. As can be seen in Figure 2, the patient is free to choose the words she wants to practice at a given stage of rehabilitation.

By training at two different levels of difficulty the patient can practice the pronunciation of sounds both in isolation and in multi-syllable words. Task difficulty is graded and multi-syllable words are practiced in order to help the patient regain the ability to make a fluid transition from one articulation to another and to combine syllables into words independently. Once level of performance has been stabilized, the aids, that is, the aural and visual model and the diagram showing the place of articulation, are gradually withdrawn thanks to a "Don't show the picture" option built into the software and the possibility of not presenting the recorded pronunciation of different sounds or words. The purpose of these options is to facilitate internalization of the applied language strategy. The aids are gradually withdrawn when the patient has achieved a stable level of speed of correct verbal responses to the presented models.

The program was developed according to the principles of computer program implementation formulated by Loverso and Prescott (Loverso, Prescott & Selinger, 1992) and it meets the following criteria:

1. It is possible to assess therapeutic outcome thanks to the inbuilt timer which measures reaction time.
2. The program is easy to master, even for IT naïve persons.
3. The patient can run the program independently.
4. The rehabilitation results are automatically registered and are not lost when the program is exited.
5. The program is adapted to the patient's progress due to the varying difficulty of the tasks.

Application of computer-assisted rehabilitation is also consistent with the principles of rehabilitation of higher cognitive function impairment recommended by neuropsychologists. Therapy is individualized and the exercises are adapted to the specific language deficits found in patients with kinaesthetic aphasia. In the tested method of computer-assisted rehabilitation, the patient utilizes aural and visual information inherent in the model recording of correct articulation and the graphic representation of the positioning of the various elements of the articulation apparatus. Once the level of performance has stabilized the additional cues are withdrawn.

The subject

The computer-assisted rehabilitation program was tested on a forty-one-year-old male patient, JB, with aphasia caused by extensive left hemisphere apoplexy. JB had a subarachnoideal haemorrhage caused by a ruptured aneurysm of the internal carotid artery on March 27, 2003. That same day he had LH temporoparietofrontal craniotomy and the internal carotid artery was closed with a Yasargil amagnetic clip. Psychological examination, conducted in April 2003, revealed severe kinaesthetic aphasia and neuropsychological rehabilitation was recommended. In April 2003, JB began his speech therapy at Warsaw Hospital. The traditional method of rehabilitation of kinaesthetic aphasia (Luria's model) in which the patient has to complete series of words and proverbs and copy written words was applied. In January 2006, JB agreed to participate in the computer-assisted speech rehabilitation program.

Procedure

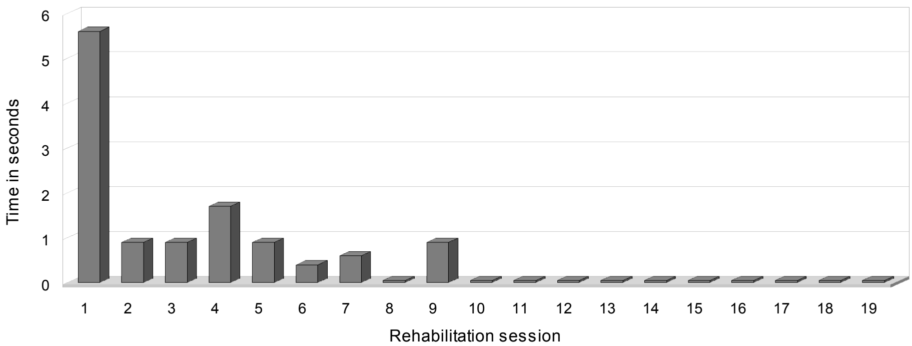
A three-step procedure was adopted in the following order:

1. Pre-test
2. Rehabilitation based on the presented computer program.
3. Post-test.

Before the rehabilitation began the patient was diagnozed using a selection of trials from the Test Battery for the Cognitive Assessment of Patients with Brain Damage (Łucki, 1995) and the Boston Diagnostic Aphasia Examination (BDAE: Goodlass & Kaplan, 1992). The patient obtained 163.5 points out of the maximum 395 in the selected BDAE trials. During the BDAE pre-test his articulation was often mispronounced and slow in the Verbal Efficiency and Automatic Series trials. He had no paraphasias. He failed the alphabet trial which he interrupted after uttering the letter A. JB got to April in the month naming trial then stopped. When uttering words he was clearly trying to configure the articulation apparatus correctly. He frequently said that he knew what word he wanted to utter but didn't know how to do it. The following trials were selected from the Test Battery for the Cognitive Assessment of Patients with Brain Damage (Łucki, 1995): Dialogical Speech, Repetition, Names, Action Names, and Colour Names. In the Dialogical Speech trial JB correctly answered the request to give his first name, second name and address but he answered none of the remaining questions. In the Repetition trial he correctly repeated the sounds: a, o, u, e, y; the syllables na, cia, ha, ta-da, za-sa, da-ta; all one-syllable words; some multi-syllable words; the series of two words, two numbers and three nonsense syllables; and the two-word sentences. He often had difficulty articulating and tried to find the correct lip and tongue position. He distorted many words (substituted sounds with other, articulatorily similar sounds). He failed to repeat the sounds ą and ę; the syllables wa, pa, pa-ba, ka-ga, wa-fa, ba-pa, sa-za, ga-ka, and fa-wa; and most multi-syllable words. In the Names and Colour Names trials he failed to name any drawing and in the Action Names trial he only named two actions correctly, eating and shaving. JB did not spontaneously initiate any utterances.

Analysis of the clinical trial performance showed that the basic defect consisted in impaired analysis of the sensory sensations transmitted from the articulation apparatus. This was reflected in the patient's failure to find the correct position of the articulation apparatus and the articulatory difficulties he had when trying to find the correct lip and tongue position. He mispronounced articulatorily similar words. He had great difficulty with the fluent pronunciation of articulatorily similar sounds, for example, wa/fa, pa/ba. He was unable to pronounce most sounds, syllables and words independently. He was much more successful with the Repetition trial. Dialogical speech was completely wiped out. JB was only able to give his name and address. Outside of the diagnostic setting he uttered a few emotionally-laden words including "mama"; Ania (his sister's name); "yes"; "no"; and "it depends".

Figure 3. Mean pronunciation time for sound A



Rehabilitation outcome

The study in 2006

It was assumed on the basis of the literature that computer-assisted speech rehabilitation would lead to first-level transfer, an effect involving swifter articulation of sounds practiced at three different therapeutic levels: using all the available cues, excluding the "recording" cue and excluding the "recording" and "graphic representation" cues.

The figures 3 and 4 show the dynamics of change in the pronunciation of selected sounds during rehabilitation.

The present study also sought to determine the effect of cue withdrawal on the speed of performance of language tasks. The differences in mean time of consonant pronunciation during rehabilitation using all the available cues and upon exclusion of the"recording cue" and between the mean times of consonant pronunciation during rehabilitation with the exclusion of the"recording" cue and with the exclusion

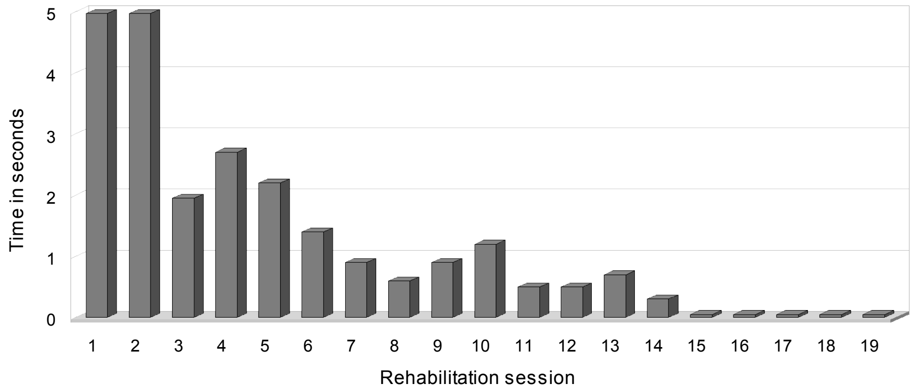
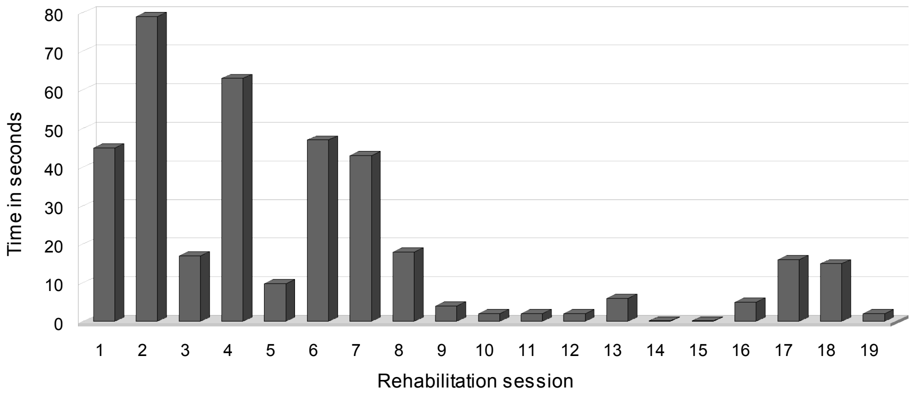


Figure 4. Mean pronunciation time for sound B

Figure 5. Mean pronunciation times for consonant C without cues



of all cues were assessed. It was assumed that shorter reaction times at each stage of rehabilitation would signify increasing internalization of the language strategies. Deterioration of outcomes at consecutive stages of rehabilitation would suggest that the patient was unable to articulate the different sounds correctly without the help of visual, auditory and kinaesthetic cues.

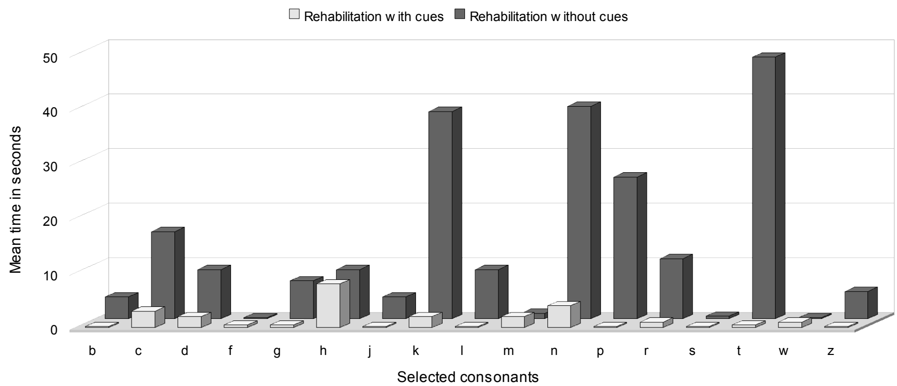
Significant differences were found between performance aided by all the cues and performance with the exclusion of the "recording" cue, and between the mean scores for performance aided by all the cues and performance without any cues, which means that the re-education had a positive effect. No significant differences were found between the mean scores for rehabilitation without the "recording" cue and rehabilitation without any cues whatsoever.

It was observed during the rehabilitation that the patient had great difficulty pronouncing some sounds. It was assumed that high mean times of sound pronunciation at the end of the second stage of rehabilitation signify persistent articulatory problems.

Figure 5 shows the mean pronunciation times for selected consonants during rehabilitation with gradual cue withdrawal.

When rehabilitation was conducted with the help of the "recording" and "graphic presentation" cues, the following sounds were most easily articulated: /b/; /g/; /p/; and /w/. The patient took longest to pronounce the following sounds: /c/; /d/; /h/; and /z/. When rehabilitation was conducted with the exclusion of the "recording" cue, the patient has least trouble articulating the following sounds: /b/; /f/; /g/; /l/; /p/; and /w/. The sounds which caused him the most trouble were: /d/; /h/; and /t/. When rehabilitation was conducted with the exclusion of both the "recording" and the "graphic representation" cues, the following sounds were articulated most easily: /b/; /f/; /g/; and /l/. The following sounds caused the patient most difficulty: /d/; /k/; /n/; /t/; and /z/.

Figure 6. Mean pronunciation times for selected consonants during rehabilitation with or without cues



The Study in 2009

The objective of the second study was to evaluate whether the effect of the rehabilitation has been preserved and it facilitated the use of speech in everyday functioning. Between the years 2006 and 2009, JB did not participate in any computer-assisted rehabilitation programmes.

In order to make the speech evaluations, the patient participated in four 1-hour rehabilitation's sessions with the use of computer-based treatment. During these sessions, he was asked to read the list of 140 unknown words and to repeat sequences of phrases consisting of: (i) two and three words; (ii) two numbers; (iii) three nonsensical syllables; (iv) two- and three-word sentences. The patient was also requested to describe a picture from BDAE (he totally failed to perform this task during the diagnosis in 2006).

Figure 6 shows the mean pronunciation times for selected consonants during rehabilitation with and without cues.

The second study showed that the patient did not find it difficult to articulate any sounds when the cues were presented.

When the rehabilitation was conducted with the exclusion of the cues, the patient incurred significant problems with the pronunciation of the following sounds: /c/; /d/; /h/; /k/; /l/; /n/; /p/; /r/; /t/. The remaining sounds were articulated correctly with normal pace.

Post-test results

One of the assumptions of this study was that computer-assisted rehabilitation would be deemed successful if its effects generalized to tasks which had not been practiced directly during the therapeutic sessions. In order to test the generalization effect, the following measures were applied: the Boston Diagnostic Aphasia Examination (selected subtests; Goodglass & Caplan, 1972); the Test Battery for the Cognitive Assessment of Patients with Brain Damage (Łucki, 1995). JB was also requested to read a list of 140 words whose pronunciation had not been practiced during the computer-assisted rehabilitation.

Following the computer-assisted rehabilitation the BDAE score improved by 20%. The greatest improvement was found in the following sub-tests: Naming, Oral Reading, Fluency, Repetition.

When JB once again took the selected trials of the Test Battery for the Cognitive Assessment of Patients with Brain Damage, he correctly repeated all the sounds, syllables, and one-, two-, three-, four-, five-, and six-syllable words. He also repeated the series of two or three words, two numbers and three nonsense syllables. He correctly repeated the two- and three-word sentences. He independently named 7 out of 10 drawings. He had to be prompted in three drawings (the first syllable was provided). In the Activity Naming trial JB named 9 out of 10 drawings. He was prompted by providing the first syllable in two drawings. In the Colour Naming trial the patient correctly named all the colours when prompted with the first syllable. JB read 105 words from the list of 140 multi-syllable words beginning with all the letters in the Polish alphabet. Twenty-four words had to be prompted.

JB was now able to use prompts (first syllables) effectively, something he was not previously able to do. The prompt was often sufficient to actualize the whole name. He also began to use words which he had practiced in stage two of his rehabilitation in everyday life. The words were well-consolidated and their pronunciation caused him no trouble.

In the second study performed in 2009, JB correctly repeated the series of: two and three words, two numbers, three nonsense syllables, two- and three-word sentences. Moreover, he correctly read 137 words from the list of 140 multi-syllable words. For the first time JB was able to describe a picture without any prompts. Despite the fact that his speech is still very limited, he used the following expressions to describe a picture: „water is dropping; a woman and cookies in the kitchen; it is summer; coffee and tea but it is difficult to say; a plate, a plate, two plates, a women is cleaning; a short dress; the children are polite but I don't know; window". In order to make his speech more comprehensive he used many gestures and pointing. He showed less problems with the production of whole words than separate sounds like consonant or vowels, which suggests that the acoustic pattern of the words is preserved.

Discussion

Analysis of the time needed to pronounce practiced sounds confirmed the hypothesis that a first level transfer effect would take place, i.e., practiced sentences would be pronounced more easily. This effect is most apparent when all the cues are used during rehabilitation. The patient needed systematically less time to pronounce the sounds. This was because his articulation apparatus was well-trained and he had learned to configure the elements of the articulation apparatus correctly when pronouncing sounds and to use cues effectively. When rehabilitation was conducted without the "recording" cue, different sounds had different learning curves. Analysis of letter pronunciation times revealed that the sound which was most difficult to articulate was /h/. This is a retrolingual sound and therefore it is difficult to demonstrate the correct configuration of the articulation apparatus during its pronunciation. Yet no such problem was observed for /g/, another retrolingual sound. The time needed to pronounce it decreased systematically. The difference was possibly caused by distinctive features of the sounds (voiced – voiceless). When a consonant is voiced this is an additional source of information which facilitates correct articulation.

Analysis of the time of pronunciation of sounds on the three levels of rehabilitation showed that the miniclip and the graphic representation act as a prosthesis of the lost function and help the patient to pronounce sounds correctly. It took 19 rehabilitation sessions to internalize the language strategy for the sounds /a/; /b/; /o/; /u/; and /w/. The time needed to pronounce these sounds was shorter at each consecutive stage of therapy, meaning that configuration of the elements of the articulation apparatus had become automated once more. It would probably have been possible to achieve such an effect with the remaining sounds had more time been spent on practice at each stage of rehabilitation.

Analysis of the mean pronunciation times for the practised sounds suggests that dorsal and retroflex sounds are the most difficult ones to articulate, probably because the patient cannot see the position of the tongue relative to other elements of the speech apparatus when pronouncing them but must take his cues from kinaesthetic memory. Meanwhile, as we know, this type of memory is impaired in patients with kinaesthetic aphasia. Bilabial and labiodental sounds are the easiest to articulate because their place and method of articulation are clearly visible via the mini-clip.

Analysis of the sentence sets used in the post-test showed that the computer-assisted rehabilitation of the patient with kinaesthetic aphasia led to generalisation of the outcomes to tasks which had not been practiced directly (second-level transfer). The following skills improved: word comprehension, recognition of parts of the body, command comprehension, oral efficiency, fluency, automated utterances, word repetition, sentence repetition, oral reading, answering the questions, naming designates, and naming parts of the body. By practicing his articulation apparatus, JB facilitated his verbal fluency. Also, the patient successfully utilized prompts (the first syllables of words), something he could not do before rehabilitation. One prompt was often sufficient to elicit a whole name. The fact that JB acquired this skill shows that he could begin to take advantage of rehabilitation methods analogous to the computer program for the rehabilitation of patients with amnestic aphasia developed by Bruce and Howard (cf. Crerar & Ellis, 1995). Finally, JB began to use words he had practiced during the second phase of rehabilitation in his everyday life. These words were well-consolidated and JB had no trouble pronouncing them.

The second study performed in 2009 has showed that despite the fact JB has not taken part in the computer-assisted rehabilitation since the year 2006, the effect of the therapy has not declined. Nevertheless he still has problems with the articulation of dorsal and retroflex sounds.

It can be also assumed that he is steadily improving and starts to produce speech spontaneously.

Concluding remarks

This is the first published report of effective application of a professional computer program in the rehabilitation of a patient with kinaesthetic aphasia and it fits into the wide range of studies on the computer-assisted rehabilitation of neuropsychological patients. The results of this study have demonstrated the effectiveness of this type of rehabilitation. The method is all the more valuable that it can be applied independently, without the assistance of a speech therapist, and this will certainly help to intensify speech therapy. The conclusions of this study are optimistic and they should encourage researchers to repeat the procedure with a larger sample of patients and to try to perfect the program and maximize the procedure's objectivity.

This study has shown how to combine traditional forms of neuropsychological rehabilitation with computer-assisted therapy. Development of a computer program for the therapy of specific neuropsychological deficits is the best way to overcome patients' problems and avoid the accusation of impersonality and lack of flexibility. It is necessary to carefully monitor not only patients' progress during the performance of computer-generated tasks but also the effects of rehabilitation on patients' everyday functioning.

The computer program for the neurophysiological rehabilitation of patients with kinaesthetic aphasia presented in this article combines the benefits of traditional forms of rehabilitation and computer-assisted therapy. Thanks to the accessibility of computers and the interdisciplinary co-operation of neuropsychologists, linguists and information technologists, the prospects for the continual enrichment of programs for the rehabilitation of patients with brain damage with elements of computer-assisted therapy are good.

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