KFKI-1978-70

L. HOLTZER
F. VAJDA

RELATIONSHIP BETWEEN COMPUTERTECHIQUES AND PHYSICALLY HANDICAPPED PEOPLE

Hungarian Academy of Sciences

CENTRAL
RESEARCH
INSTITUTE FOR
PHYSICS

BUDAPEST

2017

KFKI-1978-70

RELATIONSHIP BETWEEN COMPUTERTECHNIQUES AND PHYSICALLY HANDICAPPED PEOPLE

L. Holtzer and F. Vajda
Central Research Institute for Physics
H-1525 Budapest P.O.B.49. Hungary

HU ISSN 0368 5330
ISBN 963 371 456 7

ABSTRACT

This report summarize the recent results of attempts to develop computer-based systems for support handicapped people. The main topics are: Tactile substitute for sight. Vision substitution by auditory sensation. Application of synthetic speech. Computer terminals for the blind. Technical aids for speech training for the deaf.

АННОТАЦИЯ

Данная статья содержит результаты, достигнутые в области развития систем с ЭВМ, разработанных для людей, страдающих физическими недостатками. Основные темы данной статьи: дополнение зрения осязанием; дополнение зрения слуховым восприятием; применение синтетической речи; машинные терминалы для слепых; технические дополнительные средства для обучения глухих разговорной речи.

KIVONAT

Jelen tanulmány azon törekvések jelenlegi eredményeit foglalja össze, amelyek a hátrányos helyzetü emberek számára kidolgozott számitógépes rendszerek fejlesztésére történtek. Főbb témái: Látáspótlás tapintással. Látás pótlása hangérzékeléssel. A szintetikus beszéd alkalmazása. Számitógép terminálok vakok számára. Technikai segédeszközök a süketek beszédtanitásához.

motto: The cause of our handicap is
a physical defect, nevertheless,
society puts us into a
disadvantageous position [1.]

1. Introduction

Special aids and methods are needed for handicapped people. Children and adults who are visually handicapped /blind or with defective eyesight/, who have an auditory handicap /deaf or of impaired hearing/, those who are mentally handicapped, those who suffer from limitation of motion /crippled/, and those who with speech or any other defects, need special aids when taught by the teachers of the handicapped or when they try to find their place in life. Handicapped people have many difficulties not only in learning but in their adapting themselves to the environment of "normal" people.

They not only have to overcome their defects but they have to struggle with the prejudices which beset them day by day in utilizing the abilities which they do have.

Any aids to facilitate their education or supplement the abilities they do have could mean an immeasurable benefit for them and, in the long run, great human and economical benefit for society in general.

Judgement [2], [3], of those who are mentally or physically handicapped and their reception into society / or their being outlawed/ varies widely according to the historical age and to geographical locations.

Let's look at such well-known examples as:

- the "excursion place" of the Spartans, Taigetos Hill, from where the crippled children were thrown.
- some African tribes who respected mentally deranged people thinking of them as being saints and respecting their lives with supertitious anxiety.
- lords and kings of depraved taste who kept dwarfs in their courts in which case the the derision of their physical deformity served to amuse the noblemen.
- the sort of life the village idiots used to have in Hungarian villages and what foolish, not to say evil, jokes were played on them.

Compared with what used to happen the situation has changed profoundly. Every society takes precious care of the education of handicapped people and helpes in their

adapting themselves to that society [4].
One reason for society's concern is that there are more and more such people who need help to an increased degree.
One of the paradoxes of the rapid progress of medical science is that it has enabled many children to remain alive who, some decades ago, would have died soon after birth, and within this group there is a quite high proportion of people with some sort of handicap.

Technical development is another factor. Technical instruments enter every part of life to an almost unbelievable extent.

Let's consider:

- how naturally present-day children view space flights, landing on the moon, atomic submarines and so on. How unconcerned they are when handling instruments such as colored TV sets, automatic washing machines, tape-recordes etc. which are often complicated even for adults.

- how soon, relatively, the results of researches have found their way into our every day life /Teflon -dishes, integrated circuits, televizing between continents by means of satellites, etc./

- how the average person, with no knowledge of its principles, begins to use an instrument as a simple object without dreaming of learning how it works. In this way the "thinking brain" has become the computer and it has become natural that one no longer works for hours to obtain results, he can solve exercises much more quickly and much more accurately in the schoolroom by means of a minicomputer.

It was to be expected that societies which were always concerned about handicapped people should wish to provide them aids, and to want to help blind people not only with a white stick but with more sophisticated aids.

The situation relating to Hungarian computer techniques seems to be a bit different from this general tendency. This industrial sector began to work with a 10 - 15 years delay but nowadays complex problems are solved by systems of the Hungarian computer techniques. There are already industrial process control power stations where the whole of the measured data collection and the power distribution is realized by computers. Computers are used to evaluate obstetrical experiments, they are used for management and data processing. Hereinafter, we have attempted by gleaning the literature to give some sort of composite picture of the technical aids worked out and published for two big groups of physically handicapped people.

We have kept our summary within certain limits:

- it is a representative examination without going into detail.
- no attempt was made to deal with the listing of aids for all kinds of defect, but only for two, blindness and deafness. In the first case we set out to examine what other perception might help to subtitute for loss of sight or in what other way blind could be taught "to see". In the case of deafness those methods and aids are gathered which help in the teaching of speech to deaf people.
- in the field of computer aided education we did not deal with the realization examples of "traditional" Computer Aided Instruction /CAI/ /see, for example, ref [5]/. We should like to emphasize once more that the aim of our work was only an appraisal, it was not an attempt to find the best, most correct, and cheapest solution to the problem.

2. Technical aids for the blind

Aids for the blind can be divided into two categories. These are: reading- and object recognition, and aids to facilitate mobility. In both categories consideration is related to the tactile and auditory sensations of the person. There is, however a third category, viz.

those aids with the help of which an instrument - usable for the sighted only - can be handled by those who are blind or who have defective eyesight.

The aids introduced below, in the first two categories, are divided into groups according to which organ of sense they use as a means for subtituting vision and how they compensate deficient sight, because the same technical principles play part in both categories.

2.1. Tactile subtitute for sight

Blind people try to replace sight with their tactile sense. The traditional way of doing this is by Braille reading and writing. We will deal with the technical news of Braille writing later. The first simplest and perhaps the best-known instrument for reading traditional print is Optacon /Optical to tactile converter/.

Experiments relating to the designing of Optacon began in 1962 [47] at Stanford University /USA/. The first publications of results date from 1966. The original device, which is practically equivalent to the most recent one, was manufactured in 1971. The basic principle of it is the optical-to-tactile image conversicn.

Optacon, as do other reading machines, consists of three main parts:

The input information converter unit involves a small optical sensor with a zoom lens. In this part, for instance, there are six columns, each with 24 photo-transistors. This optical unit converts the imaged letter to a raster image of 144 points.

The processor is even able - among other things - to regulate automatically the perception depending on what paper the letters are written on /i.e. whether the paper is matt, glossy, etc./.

The main duty of the output unit is to transfer the information to a vibratory stimulus on a 24 by 6 array of pins driven by piezoelectric bimorph.

The blind person places the distal phalange of his forefinger on this array, while his other hand moves the optical pick-up probe above the text to be read. The part perceived by the detector being black results in an increase of about 65 μ in the vibratory field and, during vibration, causes a tingling feeling on the forefinger which is on the corresponding place of the Optacon.

Several thousands of Optacons are in use all over the world [6]. Experience gained up till now is summarized in the following.

Any texts can be read by means of Optacon after a certain amount of practice. It is particularly important in two ways. One of these being actuality, since this cannot be assured in any other way except by the small quantity of Braille newspapers available. One must not forget, however, the help given by computers in the preparation and translation of Braille writing [7], [8]. On the other hand, any printed matter can be directly read with the help of Optacon /without the need for translating into Braille/, from post office order forms to labels on medicines; from handwritings to newspapers.

According to the experiments realized up till now, a 92 - 98% reading accuracy can be obtained with a reading rate of 50 words per minute after roughly 120 - 150 hours of practice.

Among those who were taught to use Optacon in Heidelberg, FRG, only two unsatisfied subjects were found during a fact-finding investigation some years later. Those two persons had stopped using Optacon. The others were making good use of it either in their work or in their private life.

By 1975 in the USA, not only adult blind people were using the device in their work but many school children and university students were able to learn with its help.

The favourable reading results inspired the designers to try to extend its range of application to other fields. The 6 by 24 vibrator array, playing the part of a sensor, and tactile display, was changed to one which was 12 by 12. This was to be used for <u>pattern recognition</u>. [9]. /The tactile vibrator was placed on the handle of the perceptual camera; in this way, as the blind person directed the hand-camera to the object, he could sense its image on his finger immediately - though in a very rough form.

As a further applicational experiment, the modified version of Optacon was tried for <u>environment sensing</u>. It was found not to be suitable for this purpose but it is noteworthy that the performance of blind subjects using the tactile display matched that of the sighted subjects using a corresponding visual display.

As a matter of fact, the basic idea of the Optacon was used in the design of another tactile aid too. This time a 20 by 20 array of stimulators was mounted on the back of a dentist's chair. Thus, the blind people were able to perceive the stimulating effect while resting their backs against the perceptional array, [10]. The blind subjects of this experiment /one of them a phychologist blind since the age of four, the other five from birth/ were able, after 150 hours of experience, to recognize not only common objects such as a telephone set, cup, glass and so on, but to sense perspective and overlapping objects too.

With the aid of this device, the motion of persons standing before the camera and their individual characteristics such as: height, hair length, presence or absence of glasses could be perceived [11].

2.2 Vision substitution by auditory sensation

Several researches have already studied the problem of providing the blind with such a relatively simple device which tries to compensate the absence of their sight with the help of their unimpaired auditory sensation. A lot of suggestions have been proposed ranging from the simplest to the most complicated machines. Neglecting those solutions where electronics is represented only by a tape-recording the reading made by a sighted person; the help given by electronics and computer techniques in the already realized solutions means the perception of an object by a certain aid /photocelle, phototransistors or TV cameras and so on/ and the transformation of the image to acoustic phenomena.

Among the previously realized devices, the Optophone was invented by the English physicist E.E. Fournie d'Albe [12], in 1913. It uses light sensitive detectors as sensors, arranged in a vertical column. According to the place of the detectors the device produces tones of different frequency depending on the detectors being subjected to light. Tones of different pitch belong to each detector in the vertical column. The highest pitch belongs to the top, the lowest one to the bottom of the column. If, for instance, the device senses the letter "I" /a vertical line/ all the tones sound at the same time; if it senses a dash-rule, a certain pitched tone sounds for longer. In the case of these two symbols, recognition is easy but the common ones are much more complicated so their recognition is quite different.

Recently, the stereo-technique has been used to improve this method. In the earphone the high tones sound more strongly in the left side, the low ones in the right side. Thus, the usually excellent ability for voice-direction recognition of the blind has enabled a new dimension to be applied.

The Batelle Optophone, the Visotoner, Lexophone, and the Cognodictor work on a principle similar to that of the Optophone.

The newer methods utilize fundamentally equivalent principles:

- an instrument - such as a reading aid - produces different sound signals or tones to each letter or word.
- at the transformation of the image of an object to sound signals, the position of the different points of the object in the system

of coordinates is coded as the changing of frequency and sound intensity.

In the case of the first variation a window is moved above the text. The "window" is a sensor of photo-transistors and produces different combinations in the vertical column according to the black and white ratio. A minicomputer,belonging to the system, attach a certain "musical code" to the combination of the sensor frequency. /There were such variations where the device stored impulses until the end of the word and then emitted a single pattern of sound for the entire words.However, this meant great engineering problems. Additionally, it also can be said or this method that the concentration needed to decipher the code was apparently great and wirds of more than six or seven letters had to be repeated two ot three times to be recognized. Since great concentration was needed for decoding, relatively small energy was left for interpreting.

Other solutions promise easier methods with less concentration needed than the "musical code". Each letter is characterized by a short, individual melody. For example, the letter "k" is a strongly upward moving melody, the letter "u" is a low pitched even sound, "m" means three clatters, "v" "n" "x" "z" have characteristic trills of different pitch and so on.

Although the device processes the letters one at a time, the human observer tries to understand them as averages.

Without doubt the limited experience gained up till now has shown that the longer the word, the more difficult the recognition. A better understanding rate was shown in the case of shorter words after the same period of practice.

For the other kind of solution /when the changing parameters are frequency and sound intensity/ an electronic image scanning is carried out. The frequency of the sound indicates the momentary vertical position of the scanning, the sound intensity indicates the horizontal position of it. The used frequency range is between 200 and 5000 Hz. There are other factors which can form the frequency limits at another way. For example, older people perceive the sounds of higher frequency in a specific way, thus these must be regulated individually. Some peoples' hearing loss can be compensated by turning up the sound intensity to the affected ear.

It is desirable to increase the speed of the scan when no sounds are presented to the blind /e.g. when no objects are encountered/. If this could be realized, the whole scanning time would be better utilized.

Although there is a limit to which one can reduce time between tone bursts, it has been established experimentally as eight milliseconds.

Solutions were sought for the following problems when using the different devices:

- to what extent can the pattern be complex which is identifiable after hearing.
- how quickly can the patterns of different complexity be represented
- are there subjects able to perceive the distance between themselves and the objects being seen by the TV cameras?

The following experimental results have been published [13]:

- experimental subjects were able to identify the position of different dots, vertical, horizontal and inclined lines in one level. Eighteen patterns were taught to the subjects during half an hour. After a short practice they could also recognize patterns which did not exist among the earlier eighteen. Thus, it is shown that they not only remembered the patterns but also understood the use of the system.
- in the case of using a flying spot scanner system, 10-year-old blind children were able

to identify many patterns, for example stars of 5,6,7,8,9,11, points

- four hours were needed to teach the eighteen patterns but more time was necessary for more complicated patterns. During a later test, six blind people were able to identify 14 or more patterns after some practice. There were unknown patterns in this test too, nevertheless, the blind subjects could recognize them. Thus, it was proved again that the working principle of the system was understood during the teaching process.
- a 10-year-old blind child could identify 7 different objects with just one hour of training by the application of a camera system. /Each scan lasted 8 seconds and generally two scans were needed for identification./ The objects were: snippers, pair of pincers, pair of scissors, screwdriver, jug, hammer. Generally, blind people needed twice as much time as blindfolded subjects for the identification of the objects.
- the following patterns were identified: square, triangle, star, and others. By means of this system the problem was examined whether a blind person could get information from a TV camera about the spatial position of an object.

Although the answer is positive, the time needed for realizing the certain motion was too long.

After learning the system for recognizing patterns, a 39-year-old blind person was permitted to practice the spatial arrangement for a period of 15 minutes. After that he could walk among chaires very slowly with the help of the camera.

The "bat system" is mentioned separately. This is a device on the head which produces ultrasounds which will be reflected on the object. The reflected ultrasound is coded to audible sounds for the blind in three ways:

- the pitch-level of the sound changes according to the distance the ultrasound rebounds from.
- the change in the intensity of the sound depends on the size of the object.
- the sound is clear or fuzzy according to the form of the object.

This ultrasound producer device would not have been mentioned /in the same way that the ultrasound white stick and the laser-ray stick have not been mentioned/ if it had not been used to prove an interesting theory in a remarkable way.

According this theory [14] people originally have the characteristic that their sensations, perceived by the different organs of sense, interact with each other and one has not to learn that seen objects can be touched and heard sounds have visible sources.

Thus, if the blind child is born with a perceptual system ready to seize on abstract information of a certain object, no matter what the method of the presentation was, the child would be able to use the information in this artificial form if it had the same formal properties as natural information. It should not mean more difficulty for a blind child to use artificial auditory information than for a sighted child to use vision.

Starting from this theory, experiments were performed with seven-month-old babies and it was found that a congenitally blind baby "sees with his ears". Our above mentioned device - which irradiates the environment with ultrasound and converts reflections from the objects into audible sound - was placed on the head of some months old babies and they shortly /in half an hour/,"learnt" how to evaluate sound changes heard in their earphone. They unhesitatingly found the object which was in front of them.

This experiment is noteworthy not only because it has practical consequences but because the principle involved too. A high level interaction between the device and its user can be observed here. In consequence, the substitution of an organ of sense with another one is realized in such a way that the aid not only builds into the human nervous system but also becomes a part psychologically, and determines the mechanism of perception.

2.3. Application of synthetic speech

The fact that blind people are unable to read written and printed matter in the traditional way fundamentally determines their place in society as well as affecting their every-day life as well as their professional and their cultural development. Braille texts - at a great expense, with much tedium, over a long period of time and with narrowed down thematics - were the only possible sources of materials for the blind. However, researchers of the different disciplines of sciences began a long time ago to deal with the problem of making it possible for the blind to read the writing of sighted people. Even out the outset, it seemed that solving this problem would need the collaboration of technical experts and scientists of several fields of science. As a matter of fact, the process of reading is in close connection with intuitive qualities which cannot be substituted by technical aids. Thus, the technical experiments which lasted several years and the methods resulting from these experiments tried to solve the problem mostly by using the intuitive capacities of the blind.

It was realized in every case that the task of the "reading blind" is to recognize the different characters.

The signal of the simple pencil-like optical sensor /which the blind person moves with his hand on the lines of the printed text/ is either changed into a different pitched sound depending on the geometrical situation of the letter parts /e.g. Optophone/ or the letter is imaged into tactual form /Optacon/.

The main problem of such systems is that not every blind is able to learn to use them, they contain a lot of error possibilities in character recognition and, what is more, are slow.

Computer techniques have helped further the development. Namely, the character recognition with the help of the computer system appeared more and more to be a general requirement of large-scale computer data processing. Character reading equipment enabled the text to be translated into machine codes generally utilized in computer techniques.

Unfortunately, these systems are large-sized and too expensive at present /especially, if recognition of the different type and dimensions of the letters is considered as a natural requirement/. Thus, blind people will not be able to have direct reading aids at home for several years yet. [15]

At the same time, these devices provide the possibility for the translation of information in machine coded form into Braille and, moreover, for large-scale production of this information.

The "reading machine" means, of course, the "up to date" solution [16]. There are still many problems to be solved before it reaches its producible form. The final product itself - synthetic speech generation - [17] , can be regarded as a technically solved problem: it means computer controlled sound production realized by electronic equipment.

Early experiments for speech generation - e.g. word-storage system - are already outworn. These experiments required a very large memory /about 50 thousand bits of digital storage for storing an average word/ and much human work for assembling a vocabulary of ten thousand words. The only method which has been proved in practice is speech systhesis [18] , where the text is modified according to the pronunciation. The machine assembles the different sounds from their components. Fortunately, the required modification is not so complicated in the Hungarian language as it is for English-speaking countries. /English spelling and pronunciation is different and hardly formulable/ [19], [20], The stress and intonation rules - necessary for understanding words - are also simpler in Hungarian, so the modifier part of the program can be prepared more easily in Hungarian.

With the contemporary development of perception equipment, the problem of character recognition, transmission, and speech generation in a centralized way can be imagined to be solved with the help of terminals connected by a telephone set to a large computer centre. In this way, generated speech would answer via a telephone to the input signal of the blind reader's optical character recognizer [21].

Centres for transforming printed materials /e.g. school text books/ into speech recorded on a tape could mean a simpler but perhaps an earlier realizable service [22]. A high speed recording method /a rate of thirty to forty times faster than natural speech/ could be used here since synthetic speech generation makes it possible.

Several factors have to be taken into consideration in appraising the systems which are still in an experimental state, these are partly human factors /e.g. intelligibility, thus acceptiability of synthetic speech/, partly technical-economical ones /size of the needs, expenses involved in purchasing and in operating/.

2.4. Computer terminals for the blind

The possibility for the blind to approach computer techniques or to approach the information stored in computers has become much greater with the spreading of computer techniques in the different spheres of society [23] . Here we are not dealing with such man-machine interaction, when the computer helps to overcome defectiveness /see. section on speech training for the deaf and dumb/ or takes part in the establishment of the connection necessary in everyday life /e.g. communication with people limited in motion/. Our investigation concerns only the blind. Three fundamental fields of man-machine interaction are distinguished here:

- ensuring the proper work conditions for computer professionals /e.g. computer programmers, program analysers/ [24]
- ensuring the application of computers of computer terminals /e.g. in the form of access to a certain data bank/
- computer-aided education /e.g. in the form of CAI - Computer Aided Instruction/

All three fields involve several different computer techniques and instrument requirement.

Here, only certain main features are enumerated.

With regard to the terminal /first of all we think about the terminal placed far from a time-shared big computer system/, an interactive connection supposed, so the display or the teletype modified for the blind means the up to date solution. Hard-copy has a special significance in the case of blind users who are unable to check the input visually. /Apart from other considerations, direct Braille feed backing is impossible because both hands are occupied on the key-board/. A sighted teacher can make connection to the problem with the help of this hard-copy. The application of the terminal with a Braille output /MIT-developed Braille page-printer/ [23] ensures the application of the traditional terminal configuration for the blind. However, this application raises a lot of problems which are only partly solved or are not yet solved at all. Some of these are listed below:

- the traditional terminal format cannot be kept because of its size /72 or 80 characters per row/ [23]
- it is difficult to print out a bigger amount of information /a suitable format cannot be realized; thus, the blind are unable to carry out quick checking, e.g. in the case of the program-list error messages where the

faultless part can be emitted when checking/ [25] .

- the original <u>deficiencies of Braille</u> in computer programming /e.g. the opening and closing parentheses have the same code, the symbols of the numerals are absent [26] and a number symbol followed by a number-mean letter is presented instead, and so on/.
- the formation of the Braille embossing unit makes the <u>checking</u> difficult <u>during typing</u> or even makes it impossible /inward embossing is used generally/.

In spite of the problems - which are reconcilable /e.g. with the help of the Braille system defined by MIT/, blind programmers are able to use computers successfully and the number of chief-programmers /program analysers/ is increasing too. [2]
There are different requirements, of course, in the terminal designation depending on whether it is a professional device of a <u>software house</u> or a portable one for working at home [27] .

2.5. Calculators for the blind

The various <u>calculators</u> /electronic pocket- and desk top ones/ are more and more becoming the usual belongings of everyday life. Moreover, the general use of calculators is indispensable for certain working spheres /such as, for example, in engineering/. Several research and manufacturing institutions are now dealing with the problem of helping people with little or no sight in calculator usage.

The simplest solutions to this problem are by attaching to the calculator a separate unit which enlarges the display. /For example, adapters for the pocket calculator of the Swedish firm "Project" of the desk top calculator of the Swedish firm "Talub"/ [28].

The various so called "speaking calculators" are very useful for solving the problem of calculator usage for blind people or those with impaired sight. /For example, the Resulton 11 type desk top calculator of the Swiss firm Enterzeag/. However, their high price very much limits their use even in the well developed countries.

These devices loudly read out the result - digit by digit - after finishing the computing operation. The voice, giving the different numerals and the sign - similarly to the principle of sound-film - was fixed in sound-cylinders. The sound form of a certain digit of the result is obtained by transilluminating the part belonging to the given numerals of the result. The reading rate /1-2 words/ sec. can be changed and there is the possibility for repetition. The advantage of the device is that the calculator can be switched to any languages simply by changing the sound-cylinder. [29]

A much cheaper solution was chosen by those designers of calculator adapters who ordered sounds of different pitch to the value of the different numerals. Their operation, of course, is more difficult to learn but probably the use of it does not mean an insoluble problem for the blind who usually have keen hearing. /such units can be connected, for example, to the pocket calculators of the firm "Project" where the acoustic read out can be controlled by touching the contacts ordered to the different digits./

The different Braille interfaces mean a further possibility of solution. Recently, the component's cost of such a unit is well below $ 100 [30]. The read out is realized digit by digit in serial form of changable speed started by a microswitch. The blind user keeps his hand on the adapter and the digit is given to him - in transformed form - with the help of small pins moved by relays.

The use of each mentioned system raises several common problems not yet mentioned. Just two of them are pointed out here: overflow /the result exceeds the number of digits/ and the possition of the decimal point have special importance among the several kinds of mistakes. Thus, a differentiated sound is needed to draw attention to the overflow and the place of the decimal point has to be defined unambiguously - e.g. by an irregular signal among the serially read out numerals.

/We mention here those aids too which enable people of little sight to read letters of normal size magnified twenty times on a TV screen./ [31], [32]

3. Technical aids for speech training for the deaf

Technical devices can help people of impaired hearing in two different ways. We do not deal with hearing aids which help those with the defective hearing. In our opinion, there are on one hand already worked out methodes and devices in this field which need only be developed. On the other hand, it is not the field for treatment of backward and defective children. We deal with the other kind of devices which enables people deaf from birth to learn correct speech with all its associated features.

At one time, it was almost impossible for children born deaf to learn the "normal, natural" speech with the learning methods used till now [33]. If a deaf child's speech-learning is compared with that of a child of good hearing it will be clear that perhaps the most important part of the speech-learning process /to hear somebody's - in most cases the mother's - speech as a pattern, to try to imitate it, and then to try to speak in the same way as the pattern/ is absent in the case of a deaf child: he does not hear the pattern, nor even his own voice.

It is easy to imagine how difficult the learning of the correct voice-production can be and how profitable it is.

Electronics is used in spech training and for the correction of speech features of deaf children to transform the patterns and the child's voice to another form for comparison [34].

The transformation representation is realized in two basic forms: a tactile form, and a visual interaction.

Although the tactile indicator appeared earlier /as far as we know the first such device was produced in 1925/ we discuss firstly the <u>visual displays</u>.

The form the visual displays are can be of two kinds: oscilloscope [35] or TV screen. The basic devive is the cathode ray tube in both cases, thus, the two kinds of equipment can be discussed together.

Ignoring the day-dreams and predictions of over a hundred years ago - and one of them is from the father of the telephone inventor /who dealt with deaf children's teaching and whose son got the basic idea of the telephone while examining the speech of deaf children [35] /, we can regard the first successful visual displays as having originated in the 1940s. The opinion of Bell's father was that if speech could be seen by deaf children they could learn to speak easily. The first basic ideas and devices were born after the Secons World War and they have developed to a remarkable extent during the last three decades. The basic idea is that different sensors are attached to the speech organs /microphone, accelerometer, vibrometer, etc./ which perceive the state or motion of one of the characteristics and displays this state or motion on the TV screen together with the pattern produced by the teacher. Thus, the child sees the signal of the patterns [36] together with the signal of the sound produced by himself - feedback [37] is realized. In this way, he can learn to make work his speech organ just examined [38].

This device was used till now for the examination of the following characteristics: [39]

- breath control /breathing/
- larynx adjusting
- pitch [40]
- loudness
- nasality
- timing
- rhythm
- intonation, tone
- mode and place of articulation
- where tongue is placed in the mouth
- unique articulation of different sounds
- stress
- production of voiced and voiceless sounds and so on [41]

These comparing signals can be stored, called repeatedly, and can be compared by the computer. There is a possibility for the generation of indication lines on the TV screen acomodating themselves to the child's psyche. For example, the computer draws a basket on the display and a ball - the motion of which can be controlled by pitch - has to be put into the basket within a certain time among different lines playing part as obstacles [42]. The computer even has possibility to increase the motivation, thus, it can reward successful experiments /by the appearance of a smiling face, by writing out a complimentary text, or by projecting a short cartoon [43]/.

Of course, these experiments for teaching and training correct sound production are not yet complete. The next step being to examine whether improvement is possible in the case of normal speech after finishing the training. The answer has been found to be an unambignous yes.

The first tactile speech aids had already appeared before the Second World War /Teletactor 1925, Vocoder 1936/ [44]. The basic ideas have still not changed. The deaf person can sense the sound - and speech characteristics - transformed by sensors. The connection between loudness and vibration stimulus is obvious. In the same simple way the sound can be divided into zones of frequency filtering and, stimuli belonging to these zones: stimulation by different fingers. In this way, the perception of the original pitch is rather simple.

Especially pitch [45] and intonation [46] can be indicated well by the tactile displays. Good results have been achieved with the application of tactile displays used for improving these characteristics.

To sum up, the visual and tactile indicators cannot help deaf people to hear again but they are excellent aids for learning a well-articulated, well-stressed, understable "intelligent" speech even in the case of a hearing impairment which occured prior to the formation of speech readiness.

References

1 D-Day for the Disabled
/Time, May 30,1977./

2 T.Wiseman DP industry doing its share for handicapped?
/Computerworld, May 16,1977.Vol.XI.No.20./

3 T.Wiseman DP seen as good work for the deaf but training lags
/Computerworld, June 20,1977./

4 M.J.Norwood Future Trends
/American Annals of the deaf, Oct.1974. Vol.119./

5 L.B.Culbertson CAI-beneficial teaching tool at Texas school for the deaf
/American Annals of the Deaf,February 1974. Vol.119./

6 J.I.Lindström Access to writen material for the visually handicapped-talking books and reading machines
/The Visually Handicapped,No.9.March.1976./

7 H.Sülau Braille-schrift durch computer vereinfacht
/Umschau 77 /1977/ Heft.3. /

8 P.A.Fortier Computer work for Braille-production
/International Computing Symposium, 1975, North-Holland Publ.Co./

9 J.C.Bliss-M.H.Katcher-C.H.Rogers-R.P.Shepard Optical-to-tactile image conversion for the blind
/IEEE Transactions on Man-Machine Systems, Vol.MMS-11, No.1. March 1970./

10 P.Bach-Y-Rita- C.C.Collins- F.A.Saunders- B.White- L.Scadden
Vision substitution by tactile image projection
/Nature, Vol.221.8.March,1969./

11 L.Scadden
A tactual substitute for sight
/New Scientist, 27 March 1969./

12 M.P.Beddoes,
An inexpensive reading instrument with a sound output for the blind
/IEEE Transactions on Bio-Medical Engineering, Vol.BME-15, No.2.April 1968./

13 R.M.Fish
An audio display for the blind
/IEEE Transactions on Biomedical Engineering, Vol.BME-23,No.2. March 1976./

14 T.Bower
Blind babies see with their ears
/New Scientist, February 3, 1977./

15
Machine for blind reads printed page aloud
/Design News/2-23-76/59./

16 P.W.Nye- J.D.Hankins- T.Rand- I.G.Mattingly- F.S.Cooper
A plan for the field evaluation of an automated reading system for the blind
/IEEE Transactions on Audio and Electro-acoustics, Vol.AU-21.No.3. June 1973./

17 F.S.Cooper- J.H.Gaitenby- I.G.Mattingly- N.Umeda
Reading aids for the blind: a special case of machine-to-man communication
/IEEE Transactions on Audio and Electro-acoustics, Vol.AU-17,No.4. December 1969./

18. J.Allen
Reading machines for the blind: the technical problems and the methods adopted for their solution
/IEEE Transactions on Audio and Electro-acoustics,Vol.AU-21.No.3. June 1973./

19	W. A. Ainsworth	A system for converting English text into speech /IEEE Transactions on Audio and Electro-acoustics, Vol.AU-21.No.3.June 1973./
20	C.H.Coker- N.Umeda- C.P.Browman	Automatic synthesis from ordinary English text /IEEE Transactions on Audio and Electro-acoustics, Vol.AU-21.No.3.June 1973./
21	M.Upton	Handicapped kids learn at home via cable TV /Computerworld, Aug.8,1977./
22	W.Jaeger- A.Blankenagel	Reading aids for blind persons-technical possibilities, practice up to now, and future development /The Visually Handicapped, No,9.March,1976./
23	G.F.Dalrymple	The Braille-computer terminal /The new outlook for the Blind,Vol.69, January, 1975./
24	M.A.Rahimi- J.B.Eulenberg	A computing environment for the blind /National Computer Conference, 1974./
25	J.M.Jenkin	The use of a computer in the education of the blind /Journal of Institut of Computer Science, Vol.15, 1974./
26		New Swedish computer alphabet is based on Braille /The new outlook for the Blind, Vol.65,1971./
27		New program offers computer terminals in home or office /The new outlook for the Blind, Vol.65, 1971./

28		/Univerzum, 1977/7/
29	C.P.Janota	Powerful calculators for the blind /Electronic design 5, March 1.1977./
30		Brailletron /The Visually Handicapped, No.9,March 1976/
31		Lese-schreib-gerät für sehbehinderte /The Visually Handicapped,No.9,March 1976/
32		Fernsehlesegerät für stark Sehbehinderte /The Visually Handicapped,No.9,March 1976/
33	R.S.Nickerson- D.N.Kalikow- K.N.Stevens	A computer-based system of speech-training aids for the deaf /National Computer Conference, 1974./
34	H.Levitt	Speech processing aids for the deaf: an overview /IEEE Transactions on Audio and Electro-acoustics, Vol.AU-21.No.3,June 1973./
35	M.H.Coppell	The storage oscilloscope as an aid to speech teaching /The teacher of the deaf,Vol.73/1975./
36	R.S.Nickerson- K.N Stevens	Teaching speach to the deaf: can a computer help? /IEEE Transactions on Audio and Electro-acoustics, Vo.AU-21,No.5,Oct.1973./
37	R.Lucas- R.Thorburn- D.M.Wood	Some visual Aspects of aspects /The teacher of the deaf,Vol.73/1975./

38	I.Gitlits	The use of visible speech apparatus in Russian schools for the deaf /The teacher of the deaf, Vol.70/1972/
39	R.G.Crichton- F.Fallside	Linear prediction model of speech production with applications to deaf speech training /Proceedings the Institution of Electrical Engineers,V.121.No.8.August 1974/
40	A.Boothroyd	Some experiments on the control of voice in the profoundly deaf using a pitch extractor and storage oscilloscope display /IEEE Transaction on Audio and Electro-acoustics,Vol.AU-31.No.3.June 1973/
41	A.Boothroyd- P.Archambault- R.E.Adams- R.D.Storm	Use of a computer-based system of speech training aids for deaf persons /The Volta Review,March 1975/Vol.77./
42	J.R.Allen	Current trends in computer-assisted instruction /Computers and Humanities,Vol.7,1.Sept.1972/
43		Toy monkey encourages handicapped children to speak /Design News,Vol.29,No.10, May 20, 1974./
44	J.M.Pickett	Some applications of speech analysis to communication aids for the deaf /The Volta Review,March 1971/Vol.73./
45	T.R.Willemain- F.F.Lee	Tactile pitch feedback for deaf speakers /The Volta Review,December 1971/Vol.73./

46 W.D.Stratton Intonation feedback for the deaf through a tactile display
/The Volta Review, January 1974/Vol.76./

47 M.W.Moore, J.C.Bliss The optacon reading system
/Education of the Visually Handicapped, March, 1976/Vol.7./

62.594

Kiadja a Központi Fizikai Kutató Intézet
Felelős kiadó: Sándory Mihály
Szakmai lektor: Csákány Antal
Nyelvi lektor: Harvey Shenker
Példányszám: 170 Törzsszám: 1978-987
Készült a KFKI sokszorosító üzemében
Budapest, 1978. október hó