

Psychological characteristics of visual information perception of students with visual deprivation in training to work on a personal computer

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This article discusses how children with profound sight impairment perceive visual information from a computer screen by means of synthesized speech, and describes research of characteristics of user skills development in children with visual deprivation. We provide the most significant results of research and a number of methodical recommendations on educating children of this category in work on the personal computer without visual control.

1. Introduction

Those who are not experiencing difficulties related to impaired sight most often don't think of how the processes of perception and of visual information are carried out in a blind person. As a result, the considerable part of information environment is inaccessible or has essential restrictions for people with a visual deprivation. When interacting with visually organized environment a blind person needs a mediator to promote transformation of visual stimuli into accordingly acceptable modality. In some cases, transformation can be distorted due to subjective evaluations and judgment of the mediator (for example, picture description).

In visual perception of normally seeing person the processes of examining objects include at the same time simultaneous and successive modes of information processing. However, a blind person in most cases has only access to successive mode of object perception. Drawing an analogy between operation of visual and tactile analyzers we can suggest that the simultaneity of perception of the blind is limited by the object's size, that is, the object being perceived has to fit completely into a hand. In tactile identification the same conditions are met, as in the visual one: object examining, defining its main characteristics, establishment of the relations between characteristics, etc. The essential role in formation of visual representations and understanding of the spatial relations between objects is played by a

period during which the person possessed sight before its loss, meaning that the later visual deprivation occurred, the visual representations were formed in the blind person.

Understanding problems of the blind related not only to perception of visual information, but also to its adequate transformation first of all is necessary for those who are engaged in teaching information technologies to blind children.

In the beginning of the XXI century it is difficult to find a field of activity in which computers wouldn't be involved. Universal implementation and continuous improvement of information technologies significantly changes life of the modern man, and especially the person with a visual deprivation. Constantly expanding range of digital blind aids creates demands towards visually impaired persons to have special training for effective use of this equipment.

Use of non-visual information access software significantly extended the limits of information available to the blind. Emergence of such programs can be compared in significance to the invention of Braille system.

Programs of non-visual access to information (Screen Reader) are special software allowing blind people to work at the personal computer. In their function they are similar to "seeing assistant" who finds text information on the computer screen and either reads it aloud by means of a speech synthesizer, or displays on the Braille (tactile) display.

It is necessary to note that properties of perception of information by visually impaired students, who are capable, though with restrictions, to perceive visual information, is significantly different from properties of perception in totally blind children who are guided only by the synthesized speech and the Braille information output. In this article we discuss properties of perception of information during the work on the computer without visual control, and consequently the principles of teaching practice-related work methods to totally blind children not capable of using visual interface.

Our experimental work took place on the premises of special (correctional) general education boarding school of III-IV types No. 1 in Moscow; research was aimed at finding specific features of how children with profound vision impairment work on

personal computer during study course “Informatics and Information Technologies”.

Our over 20 years’ experience of teaching “Informatics” course in school No. 1 in Moscow and other schools for children with profound visual impairment showed no problems in mastering the theoretical part of this subject. Using the usual textbook for general schools reprinted in Braille font, blind school students easily learn the theoretical material. Such subjects as “Various numeral systems”, “The mathematical logic”, “Information coding”, etc., do not cause any additional difficulties related to lack of sight.

Problems in mastering this subject are related to acquisition of practical skills of using the computer without visual control. Let us look at an example illustrating work with a computer using non-visual access software. In this example and further all commands and working methods of the non-visual access program will correspond to JAWS for Windows, as the most popular software in Russian special education system.

Table 1

№	Operation	Visual method	Non-visual method
1.	<i>Context search</i>	Visual reading from screen	Reading line by line using speech synthesizer or Braille display is done by pressing «scroll down» on each page of the text.
2.	<i>Allocation of a text segment</i>	Moving mouse with pressed left button Visual reading from screen, movement of mouse is controlled visually.	Moving cursor with «scroll down» while holding «Shift»-button, controlled line by line using speech synthesizer or Braille display.
3.	<i>Copying segment of text to exchange buffer</i>	Using a command from context menu (accessed by clicking right button of the mouse).	Using keyboard combination «Ctrl + C».
4.	<i>Search for paste point</i>	Visual reading from screen	Reading line by line using speech synthesizer or Braille display is done by pressing «scroll down» on each page of text.
5.	<i>Pasting a text segment</i>	Using a command from context menu (accessed by clicking right button of the mouse).	Using keyboard combination «Ctrl + V».

One of the common tasks during the work on the personal computer is editing text information. Let's say we need to cut some lines in one paragraph of the text file and paste them in another. This task breaks up into five elementary operations. In the given example the main difficulty of non-visual mode of work consists in searching for the needed text segment. The person using visual interface is capable to see the whole screen of the monitor at once and scroll down the page to quickly find the right text. Due to combination of successive and simultaneous modes of perception, the person without visual restrictions easily solves the task of finding a certain context.

It should be noted that when performing any tasks with text, lack of visual perception ability leads not only to reduction of amount of information, but also a decrease in its quality. For example, if one needs to find the word marked with a bold-face type, the user with visual deprivation has to either move word by word, giving the non-visual access program Insert+f command (information on font characteristics) on each word, or change the settings of the program and listen to information on font characteristics change in all document. Therefore, time necessary for the blind user to perform the majority of practical tasks considerably increases, as compared to the user free from visual restrictions.

The impossibility of using visual interface causes considerable difficulties in solving practical tasks of information processing on the personal computer. Non-visual access software does not replace sight, but only allows carrying out the main operations on the computer, using speech and tactile interfaces.

So, for example, during the work in a dialogue window, the blind user, consecutively going through control elements by means of the TAB key, has to find the necessary one, define its type, the name and the current value and only after that to set the desirable value. Defining the type of control element is necessary to choose the correct strategy, allowing changing values of this element.

By means of the TAB key, it is possible to go from one control element to another. After each time it is pressed the non-visual access program will report first the element name, then its type, and then its value. Exceptions are radio buttons and the buttons to be mentioned at the end of the article.

For obtaining the speech or tactile message on the name of control element, its type and current value the Ins +Tab key combination is used.

Let us look at another example showing differences between standard and non-visual work methods. Another common task is working with a dialog box. Dialog boxes open up when saving the file in a text editor, changing settings of any program and in many other situations. Let's say, for example, we need to change value of one control element in some dialogue:

Table 2

Operation: Setting a desired value to control element in dialog	
Visual method	Non-visual method
Visually obvious operation, performed with a «mouse» handling device	Searching for necessary control element through consecutive sorting
	Defining control element type and choice of strategy of work
	Changing properties of control element
	Search for OK button and its activation

From the given example, we see that due to the lack of possibility to use visual interface, the blind user is compelled to solve a number of additional tasks: definition of control element type, choice of correct strategy of work with it, consecutive search of the element and the Ok button. All this increases time expenditures and demands additional knowledge. The average user of a personal computer is not even familiar with such concepts as "radio button", "combobox", "spin box", etc. The blind user has to master all these concepts, remember work strategies with various control elements, remember tens and even hundreds of keyboard commands, and many other things.

The main difficulty of non-visual mode of work consists in search for necessary control element, its identification and choice of a correct work method. The person using graphic interface is capable to see the whole dialog box at once and, relying on visual presentation, to execute necessary action using the mouse. As in the previous example, by virtue of combination of successive and simultaneous

modes of perception, the person without visual restrictions easily solves the task of finding and identifying a control element.

Thus, it is obvious that mastering practical skills of work without visual control causes considerable difficulties in students.

Practical use of computers in informatics lessons at special (correctional) general education boarding school of III-IV types No. 1 in Moscow, where the research described in this article was conducted, began in 1989 with the project of computerization of special schools.

The first computers in the computer education class were equipped with a hardware speech synthesizer and non-visual access software "Screen Reader". Subsequently this name began to designate all programs of this class and purpose. During these long years, we have accumulated considerable practical experience of teaching computer technologies to children with profound visual impairment.

Now teaching of the subject "Informatics" begins at this school in the 2nd grade. The whole course is divided into four stages:

1. First stage – propaedeutic (2nd – 3rd grades). At this stage, school students get acquainted with the basic concepts of informatics.
2. Second stage (4th – 7th grades). The main task of this stage – studying the keyboard of the computer in Cyrillic and Latin layouts, and also preliminary acquaintance to a text editor and the non-visual access software JAWS for Windows.
3. Third stage (8th – 9th grades). Tasks of this stage are studying the bases of file system management, more detailed (than at the second stage) study of the text editor, acquaintance to the Internet and the tabular processor.
4. Fourth stage (10th – 12th grades). At this stage, students acquire more profound knowledge on processing information presented in texts, tabular and sound forms, study more sophisticated control of the JAWS for Windows software which is giving the blind user a chance to comfortably work in any Windows applications. They also study programming bases in Pascal and bases of object-oriented programming in Delphi environment.

At the fourth stage of learning «Informatics and Information Technologies» lessons are separated into two subjects: theoretical part "Informatics" and practical part

“Information technologies“. The hours for «Informatics» correspond to a basic federal component, and hours for «Information Technologies» are organized at the expense of the subject «Technology» and school component – 1 hour of informatics and 2 hours of information technologies.

Throughout the course children have an additional opportunity to study in the second half of the day. For this purpose, there are teachers of informatics who are constantly present in two computer classes.

Such significant increase in time for the practical training on the computer is connected with high complexity of work without visual control, and the need of this increase in hours is confirmed by the experiments performed in this research.

To increase the efficiency of educational process, two teachers work in classes with more than 7 students. The reason is that, as a rule, student groups are not homogenous: some students can work quicker, some need constant help from the teacher and work more slowly. The average of 4 – 5 students per teacher provides possibility to overcome the difficulties connected with individual characteristics of each student.

After analyzing the learning material, we selected certain subjects causing the greatest difficulties in studying computer technologies for students with vision impairment. In the framework of selected topics, we performed series of ascertaining and formative experiments.

Here we provide the description of two most typical experiments confirming an empirically obvious fact that properties of perception of blind school students demand special teaching methods and materials, based on the following principles:

- a blind student’s work on computer is based on computer keyboard commands, speech and tactile messages of the non-visual access software, and also special functionality of this program, which leads to a radical change of working methods on the personal computer;
- for effective use of personal computer without visual control the student needs to master classification and structuring of the main objects of the operating system, application software and information content;

- a student with profound visual impairment needs much more time for mastering practical skills of work without visual control and performing practical tasks as compared to the student using visual interface.

Experimental work was carried out with participation of 10th and 11th grades students who are already familiar with the non-visual access software JAWS for Windows and have mastered the main methods of text editing and file system management. Students were divided into two groups:

1. blind children with acuity of vision from 0 to 0,04 (4%) – 31 persons;
2. visually impaired children with acuity from 0,05 (5%) to 0,4 (40%) – 39 persons.

The following is the experiment layout:

1. Students received the learning material in a standard form as offered in textbooks and manuals for mass schools and normally seeing children.
2. Students were offered to perform a test task, time of performance was recorded (we will emphasize that the general methods of non-visual work on the computer were already familiar to examinees, and the test task was easy to do).
3. The teacher explained the same material, but taking into account special properties of information perception of the blind user, gave as needed the specific work methods of JAWS for Windows using texture and graphic aids.
4. Students were offered to perform again a test task similar to the initial one, time of performance was recorded.

2. Description of experiments

2.1 First experiment: Work with tables

Students were offered to fill in the table 4X4 in the MS Word program. Previously the material was explained to students in a standard form (as for normally seeing). The teacher checked that students comprehended the concepts “table”, “column”, “line”, “cell”, “heading of a line and column”.

All students already knew how to work with text in JAWS for Windows at a very good level. For visually impaired students (2nd group) the text in the task was in Arial font, font size was selected individually.

The test task was offered in the Word document containing the following text:

Place each phrase from the list in the corresponding cell. For example, the phrase “red square” is located in the cell on the crossing of «square» column and “red” line. Phrases are given in the list below the table.

Table 3:

	Square	Triangle	Rhombus	Circle
Red				
Green				
Yellow				
Blue				

Red square

Green square

Yellow rhombus

Green circle

Green rhombus

Blue circle

Yellow circle

Blue triangle

Yellow triangle

Green triangle

Red triangle

Yellow square

Blue rhombus

Red circle

Blue square

Blind children (1st group) couldn't use the visual information displayed on the monitor (though some of them had residual sight). Visually impaired children (2nd group) used the visual interface rather freely, provided that the Arial font of individually selected size and a monitor with big diagonal were used. It should be noted that actually in the second group acuity of students' vision was not lower than 0,1 (10%).

Visually impaired examinees (2nd group) performed tasks with almost no mistakes, average timing was 4 minutes. 5 blind students didn't cope at all with the task, others did the work, but spent more than 15 minutes on it.

At the following lesson children were acquainted with the texture image of the table, and also with special commands of JAWS for Windows ensuring comfortable work with tables in the Word text processor environment for the blind user.

Further, according to the lesson plan, the examinees were offered to study the table below under supervision of the teacher, using the corresponding commands of the JAWS for Windows:

Table 4

Day of the week	Lesson 1	Lesson 2	Lesson 3	Lesson 4
Monday	Algebra	Physics	Chemistry	Geometry
Tuesday	Physics	Algebra	Geometry	Chemistry
Wednesday	Geometry	Algebra	Physics	Chemistry
Thursday	Geometry	Chemistry	Algebra	Physics
Friday	Algebra	Physics	Biology	Geometry

When studying the table teachers suggested the most convenient algorithm of action helped to choose a necessary command. This work went on almost individually, with no more than 4 students per each teacher. Students had to learn to quickly answer such questions as «which lesson is chemistry on Wednesday?», «what is the second lesson on Thursday?», etc.

Having mastered this special functionality of the non-visual access software during the work with tables, students tried again to solve a test task similar in difficulty to the initial test task. This time all students coped with the task! In the second group

no essential changes in time of performance occurred. In the first group average time of performance got to about 10 minutes, with very few mistakes.

2.2 Second experiment: Web page navigation

Before the task, the material on loading web pages, their structure and basic elements, was explained to students in standard form (as for normally seeing). Then students were offered to find different information on a website specially developed for users with profound vision impairment: <http://tiflocomp.ru>

Blind and visually impaired students were offered tasks identical in level of difficulty. Children using visual interface found the required information quickly enough, and blind children were compelled to read all the information on the screen before they found what they needed. Records of time showed that blind students were 4-5 times slower and this lag increased according to how far the required information is hidden in the structure of the site.

At the following lesson students were introduced to texturized image of the Internet Explorer window and schematic image of a web page. Also they were shown how to use JAWS commands to move around the structural elements of a web page.

Then test tasks on information search were offered; they were different from what was offered originally, but with same level of difficulty. This time blind students solved the task much more successfully, their lag from visually impaired was by 2 – 2,5 times, and in some cases the lag was practically absent.

Other series of experiments carried out with some other themes of the course "Informatics and Information Technologies" showed similar results, which supports legitimacy of the conclusions given below.

3. Conclusions

A person using visual interface is capable of seeing and capturing the whole screen of the monitor at once and quickly finding the necessary information due to a combination of successive and simultaneous modes of perception. Profound visual impairment demands a different way of control over text information processing activity. If normally control is exercised by means of sight, in this case it is a

control by technical means. Implementation of activity occurs via transfer to other sensory system of perception.

Modern technologies of non-visual access to information cannot provide the blind person with this simultaneity of perception of information on the computer screen. The speech synthesizer and the Braille display output information consecutively, in linear manner. When the blind user presses «Down» arrow, he perceives the text line by line from the first word in line to the last; perception in this case is successive. It considerably increases time necessary for the blind user to perform the majority of practical tasks, as compared to users free from visual restrictions.

Thus, the main condition for successful teaching of blind school students to work on the personal computer is special training of the teacher. Besides traditional knowledge in teaching the blind, the informatics teacher working with blind children has to master the non-visual work methods, know the special functions of the non-visual access software and the special teaching techniques, which take into account the information perception properties of blind children:

- Blind students need to develop an adequate idea of how information is presented on the monitor screen (for this purpose it is necessary to use texture and graphic tools and other means).
- The work of blind school student on the computer is based on keyboard commands, speech and tactile messages of the non-visual access software, and also special functionality of this program.
- For effective use of personal computers without visual control students need to master classification and structure of the operating system's main objects, application software and information content.
- A student with profound visual impairment needs much more time for mastering practical skills of work without visual control and performing practical tasks as compared to the student using visual interface.

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Keywords

teaching of blind
informatics
non-visual access
blind user

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