Multimedia Program for Training of Vision of Children with Visual Impairment and Amblyopia

Cecilia Sik-Lányi
University of Veszprém
Veszprém, Hungary

lanyi@almos.vein.hu

Zsuzsanna Lányi
Ferenc Csolnoky Hospital
Veszprém, Hungary

lanyi.zs@freemail.hu

Executive Summary

This paper first summarises questions related to partial sightedness, defines the terms of visual training and education of vision, and discusses how the faculty of vision can be developed in partially sighted persons. Special attention is given to *amblyopia*, or bluntness of vision.

Then the advantages of multimedia software in training the vision of partially sighted children are discussed. Three multimedia programs are described that can be used to train the vision of children with visual impairment.

The first one is intended for small children who have difficulty in fixating on a given target. It uses high-contrast images of increasing complexity. The investigations have shown that by training the vision of the children with such figures presented on a computer screen, their attention can be kept on the task; due to interactivity they become motivated. The program enables feedback for the teacher as well.

The second program is meant for children in the kindergarten age, the third one for children in the first few grades of school. Children perceive the tasks in these programs as games, and our experience has shown that they like to play with them. At the same time the teacher can modify the difficulty (e.g. size, contrast, colour of the presentations) and get feedback on how easily the children can identify the different tasks.

Experiments were conducted in special schools for partially sighted children. In summary, the evaluation of the preliminary experiments showed that using the computer tasks and games motivated the children.

The amblyopian child often experiences the occlusion of the leading eye as a trauma. Playing with the computer helps him or her to overcome this trauma.

The time over which our programs have been used is still too short to get conclusions on the long-term usefulness of the method, but feedback both from the teachers and parents ascertain that the children prefer the use of multimedia computer games compared with traditional paper task versions. As the final effect of both the paper versions and the computer programs is similar – it is only important to train the eyes of the children – we are confident that our programs will turn out to be advantageous also on the long run.

We would like to invite readers of this paper who deal with amblyopic children to test our programs. They can be downloaded from our WEB site http://vision.vein.hu/mmvv/ (Lanyi, 2002).

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Keywords: visus, visual impairment, partially sighted, amblyopia, visual acuity.

Introduction

Over the past two decades, the blind and the visually impaired have been witnessing striking improvements in their access to information: These improvements are caused by the general trend in society to store and distribute information in digital form and by introducing a technology that makes the computer accessible for the blind. By replacing the computer screen with a refreshable Braille display or a speech synthesizer, files stored on a computer can be accessed, and software can be operated by a blind individual. Optical character recognition software opens the world of printed material to the blind reader. Unfortunately, these most advantageous trends are confined to textual information only, whereas graphical materials are still almost inaccessible (Batusic, Burger, Miesenberger, & Stöger, 1996).

The number of partially sighted children increases year to year. There are a lot of instruments for partially sighted people (Beck, 2001), including some very new solutions (Kobayashi & Watanabe, 2002), but not for very small children. The *visus*, i.e. how well the person can read the letters of a Snellen Table or other visual acuity test, of children can be improved by early training of their vision. Our programs build on the remaining vision of these children and help them in learning how to fixate on given targets and use their eyes to search for details. This is very important as with proper training the visus of the children can be improved considerably.

Our aim was to develop programs that are attractive for the children, provide interaction for the child and feedback for the teacher, and can be adjusted to the individual needs of the patient. We developed three multimedia programs.

The first one is intended for small children and most handicapped ones. Simple high contrast images help the children learn how to fixate on targets and find similar visual stimuli in images with slowly increasing complexity. It provides simplified drawings of well-known story figures. Children learn to identify these figures and can signal for the teacher if a figure has not been identified or misinterpreted. This should help the teacher in selecting the best way of training. The program has animations too, providing short stories and songs related to the pictures. This makes the use of the program even more attractive for the children.

The second program is intended for children attending kindergartens. It contains three tasks and three games.

The third program is intended for children in the first few grades of school. It is presented as a game; the children can play with it like with a toy. They experience the tasks as games.

The teacher, who works with the children, can test and use the remaining colour sensation of the child and build upon this knowledge the strategy he/she intends to follow.

All three programs have been tested in special schools for partially sighted children and other special institutions. The paper describes the programs and details on the evaluation of the tests that have been conducted.

The programs were developed using Macromedia Director 8.5.

Partially Sightedness

The expression *partially sighted* is a pedagogical expression describing groups of patients with impaired vision. The boundaries of the single groups of impaired vision can be defined based on ophthalmologic principles. Figure 1 shows the change of visus from normal visus to total blindness.

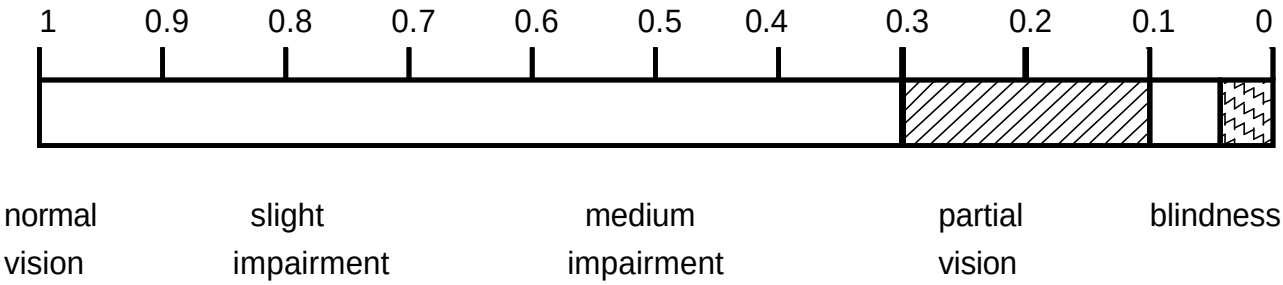

Figure 1: Visus values of different classes of impaired vision subjects.

The loss of vision to the partially sighted is difficult, nevertheless they would like to conduct a lifestyle similar to those with normal vision. To give them a chance of performing similarly to those with normal vision, they have to be helped in developing their skills; they have to be supported in their learning.

The definitions of partially sightedness differ from country to country, but it is usual to call those with a visus between 0.25 and 0.1 partially sighted. Deviations from these values can be found both at the lower and higher boundary. In some countries the higher boundary is at 0.33, and the lower boundary can be as low as 0.04. In Hungary the boundaries are at 0.3 and 0.1. One can see a tendency of lowering the lower boundary due to the fact that modern technical equipment can help the partially sighted in performing his or her task. By the help of special optical and tutorial equipment children with a visus between 0.1 and 0.05 (the class of almost blinds) can identify signs, thus can be helped to be able to "read." In recent years computers gain in importance since they can be used in the teaching of partially sighted children very effectively (CIE, 1997). Thus in determining the lower and higher boundary of the visus of a partially sighted person, individual evaluation is necessary. Important is whether the child can or cannot read and write – with the aid of special equipment – as well as children with normal visus.

Developing the Visus

The vision process can be grouped into three levels: the processing of the stimulus on the retinal level, the transmission of the sensation via the optical nerves, and the processing of the nerve-pulses in the brain. Pedagogic methods can handle and influence items of the first and third level. The development of the first level effects – i.e. the vision functions of the eye – are termed training of the vision; influencing third level sensations and brain-responses are called the education of the vision (Paraszkay, 1994).

Visual training. One way to do visual training is to supply to the partial sighted person a great number of visual stimuli. The interest of partial sighted children can be evoked by supplying them with many stimuli of appropriate size and of vivid colours. To be seen, the task has to be well distinguishable from its background, it should be the picture of an object, and it should be figurative or a well-known symbol. For small children it is important to couple the above with further items increasing their arousal. Such factors can be sounds, animations, and so forth that increase their interest and, eventually, also have an emotional impact. It is also important that the different pictures used in such eye-training and visual education tutorials should be varied, making the child curious about their content. The stimuli can be many-folded in their object (light, colour, form in a plain or in space, concrete or abstract image) and their quality (illumination, size, detailedness), distance and direction.

Education of vision. One can develop the visual thinking of children by training their ability to observe objects, to discriminate among different objects, to increase their ability to recognise forms, and to be able to distinguish between important details and background information. One can train their visual memory and their capability for association. The key element of such mental training is by solving problems.

Amblyopia

Getting optical information from our environment is critical for the development of the personality of children. Good vision can help considerably their integration into society. Children will be able to select an occupation of their choice only if they have good visual acuity. It is well known that those with visual impairment get some injuries more frequently.

Amblyopia means dimness (bluntness) of vision. The word has been constructed from the Greek words: *amblyos*, which means blunt, and *ops*, which means vision. Amblyopia is a special form of partially sightedness; it is a dimness of vision in one eye (rarely in both eyes) mostly without any organic cause, or produced during the sensitive phase of developing vision due to an organic cause. The term non-organic amblyopia is used if the visual system is healthy, the patient has no congenital or acquired illness of the visual system, and it is due to a fault of the refraction. We speak about organic amblyopia if the bluntness of vision is caused by an illness. This might be congenital or an evolutionary disorder, or due to some other sort of illness (e.g. ophtalmia: inflammation of the eye) or lesion of the eye. An organic cause will increase the amblyopia. If amblyopia has totally developed the visual acuity will not get complete, even after correcting the refractive errors. Amblyopia occurs in 2 to 5 per cent of the population (van Noorden, 1985).

The leading eye of a person with amblyopia gets damaged more easily, and this can lead to blindness. The early treatment of amblyopia is important for the society and the individual. The decrease of visual perception or its lack has profound influence also on the personality of the subject and can impair his or her integration into society (Zeischitz & Strothmann, 1990).

A general statement on amblyopia is: The earlier it can be diagnosed, the easier it is to treat it. Amblyopia develops during the first 10 years of life; later it does not worsen anymore. Usually it develops during the very first years, and if it is not recognized and treated in time, it cannot be healed at grown up age.

Thus amblyopia has to be treated as soon as possible. The important thing is to teach the not-seeing eye to see again. Even today the best method is the direct facial occlusion, recommended by Buffon in 1773; the well seeing eye gets occluded and the amblyopic eye has to function actively. The occlusion has to be continued until complete vision is regained (Yanoff, 1998).

Before treatment the refractive error (measured in cycloplegia) has to be corrected by spectacles. Both the child and the parents have to be instructed about how the occlusion has to be executed, what the probable length of the treatment will be and what the expected results are.

What are the Advantages of Multimedia Software to Develop Better Vision?

Computers attract children; children like to deal with them. Computers appeal to children more than drawing booklets. Multimedia is a synergetic means of audio, video, the written text, pictures and animations. It is well suited to show situations, it can be interactive, and it can be used to develop skills. It is the task of the doctors, pedagogues and parents to treat amblyopia and help children overcome the dimness of their vision by using computers to make children think of the occlusion of one of their eyes as a game. This will help them to better vision (Sik-Lányi & Lányi, 2001).

The Advantages of Multimedia Software to Develop Better Vision

One can summarize the advantages of multimedia in vision treatment as follows:

- It is an audiovisual medium.
- It is interactive.

- The treatment or situation can be reproduced; the same condition can be repeated several times. This can help the treatment considerably.
- The display presentation can be set according to the visus. The size, form, contrast, colour, size of line width, etc. of the objects and the background can be selected for best suiting the patient.
- It can be adjusted to the individual's needs.
- Multimedia systems have an effect on more than one organ and can be more effective.
- It can help creativity. It can be varied.
- It is like a game. (The child does not find the exercise as punishment; he/she likes it.
- The child feels the success.
- One can use motivating audio feedback.
- It can be used both in individual and small-group therapy.
- The parent can use it with success.
- Most important is that the child should get interested and his/her interest should be kept for long periods of time. This is not an easy task, but multimedia presentations are very effective in this respect.
- Using multimedia programs one can include in "games" parts that will increase the visus of the child.

Amblyopia was treated before multimedia methods were used. It is still general practice to use picture books, booklets in which the child has to draw some lines, and other materials to force the child to use its non-occluded eye. But it is difficult to select a book that suits the visus of the particular child. The books get soiled; the booklets, where the child has to do some drawing, can be used only once.

The big advantage of multimedia presentations is that they can be adapted to the visus of the child, the pictures can be re-used, no soiling will happen, and the new medium attracts the child. Thus we can state that the same effect can be reached with the computer presentation as with traditional methods, but more easily, in a more attractive way and specially tailored to the needs of the child.

Special Needs of Amblyopic Children to be Considered when Developing Multimedia Software

In some cases the amblyopic patient sees only coloured patches. It is very important for them that the single objects should be well separated from each other. For this the objects have to be demarcated from each other. This demarcation can be achieved in several ways: One way is to increase the conspicuity of the contour lines of the objects by increasing their contrast, also their colour contrast and the line-width of the contour line. It is important to use also large contrast between the object and the background. This can be achieved by selecting appropriate coloration and structure of the surfaces. The colours have great importance in developing vision too.

The Multimedia Programs

To improve the vision the following capabilities have to be developed: observation, distinguishing between different objects, and seeing forms and other important features. It is important to be able to generalize and draw conclusions. Further tasks are to improve the visual memory and develop the visual imagination.

Our programs teach the amblyopic child to recognize objects in different colours and of different size, also on different backgrounds in a playful form keeping their attention fixed.

Our multimedia programs contain many visual stimuli. Their main characteristics are that they help to train the capability of observing important details, to distinguish among the stimuli, and to help the identification and distinction among different tasks. An important point in the development was to train the

visual memory and visual thinking. We kept in mind the group for whom we developed the programs and made them user friendly. They function on single mouse-clicks; only very few keystrokes are needed.

The Required Hardware Configuration

- 16 MB free memory;
- CD-ROM reader;
- 486 processor or higher;
- 14" monitor or larger;
- Windows compatible sound card and loudspeakers;
- Mouse;
- The program is best run in 800 x 600 pixel mode, with 16 bit colour capability.

The programs have been written under Macromedia Director. They can be run under WIN 98 or WIN NT.

Description of the Programs

Program for partially sighted

The partially sighted program (Sik-Lányi, Kovács, & Varga, 1999), which was developed in 1999, is started via the start95.exe file. The starting picture permits the user to choose between the English, German or Hungarian versions by clicking on the respective flag. The main menu pops up, where one can select between different picture types. The "pictures with contrast" item lets you see some simple pictures of high contrast. The menu line "figurative pictures" lets you choose from pictures of well known objects, while the line "animations" lets you choose from among some animated children rhymes and stories. The line "settings" permits you to select colours from a palette and set the audio pitch.

Contrast images: This file contains 75 pictures. One can select the requested picture from three catalogues of 25 pictures each. These are thumbnail pictures of the full size ones; clicking one of them will show the full size picture. The colour of these pictures can be changed in the "settings" menu. At the bottom of the screen there are three buttons for navigation.

The *Figurative images* menu works similarly, but if the enlarged picture of the object is reached, one can strike the space bar and then the name of the object will be heard in the loudspeaker.

The *Animations* subfolder contains a number of short stories with well-known children rhymes. Mouse click navigation permits re-play, choosing another animation or getting back into the main menu. The content of the animations differs in the English, German and Hungarian version, as in each case nursery rhymes well known in the given cultural surrounding are used.

Game: A further menu point features an interactive possibility. The children can assemble pictures from smaller groups. They get also auditory reward if successful. As a next step a play with letters will be provided.

The *Setup menu* permits the selection of colours and audio pitch. Clicking on the single colour pallets enables the checking of the pallet's content.

The low-vision program

The low-vision program (Lang, 2000) was developed for children with low vision. The main menu has five submenus. The first submenu is useful for teachers and parents. Here they can read how one can use the program and the goal of this educational program. The next four submenus are the task submenu, the tale submenu, the game submenu, and the help submenu.

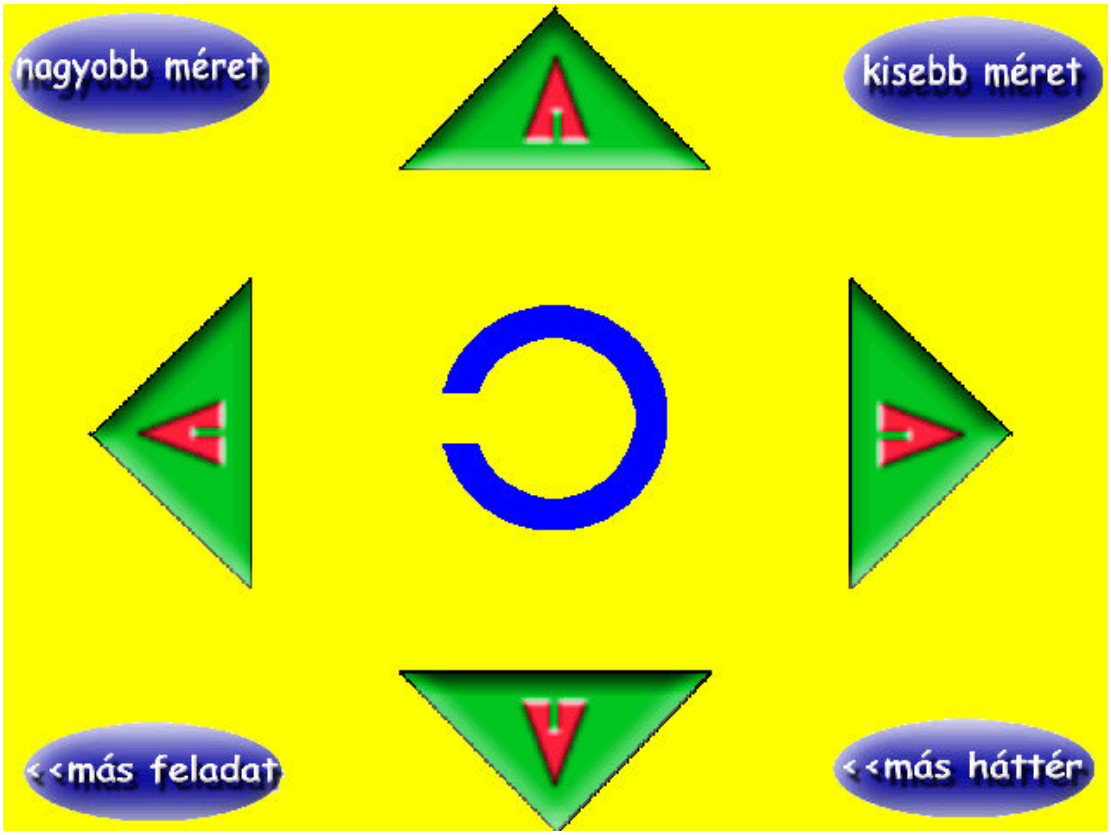

Figure 2: "Where is the opening" task. Clicking on one of the blue radio-knobs one can select larger/smaller size, a new task or other background. After seeing the "Landolt" ring, the child has to click on one of the green triangles giving an answer in which direction he/she has seen the gap in the ring.

The task submenu has three tasks. In the first task the child has to identify the direction of an opening in a ring. One can choose the background colour, the colour of the object and its size. This is usually done by the tutor. Figure 2 shows an example. Here we have chosen a yellow background and a blue object colour, and medium ring-size.

In the next two tasks the teacher has to choose first the background, then the colour of the object, then the colour of the object's frame and its size, then the figure and finally the thickness of the contour lines. This second task is called: *Look for the object*. The program paints the object somewhere on the screen (Figure 3). The program selects the place randomly. The child has to show where it is on the screen and say what she or he has seen. The last task is similar to the previous one, but it is with a little head. We called it *Where is the head?* Again depending on the severity of the visual impairment the size, coloration, contour lines, etc. can be set so that it is not too easy for the child, but he or she should not be frustrated by not being able to fulfil the task.

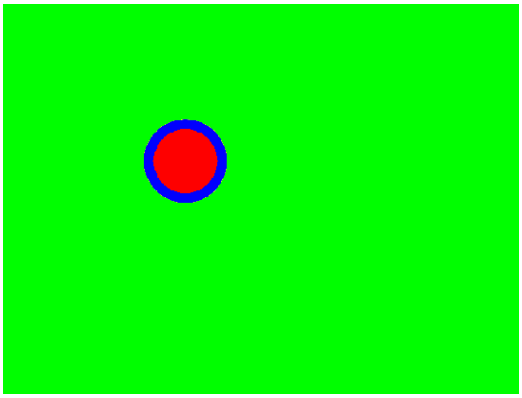

Figure 3: Task "Look for…!"

In the game submenu there are three games: *Catch it! What can you se now?* and *The mouse is moving*. After choosing the background, the colour of the object and

so on, the first game is, for example, to find and catch the circle. The objects are moving on the screen. In the second game the child has to tell what it can see. The last game gives the feeling of moving for the child (see Figure 4).

In developing the program for the tale submenu it was an important constraint that the child or the teacher should be able to stop the movement of the objects in the animations. This is important, because it might become necessary to discuss items seen in the animation.

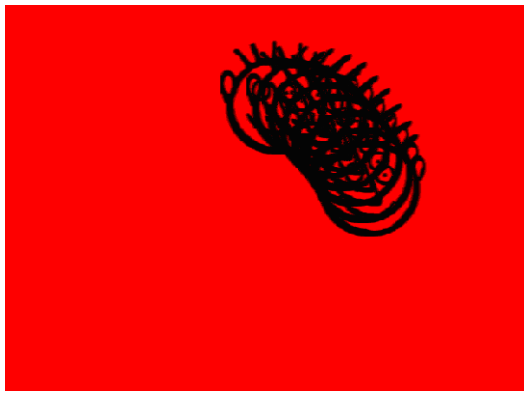

Figure 4: The mouse is moving.

Tale landscape program

Most important was the design of the main menu of our new program (Szendro, 2002) called Tale landscape. It was important to provide a well organized screen layout, but at the same time it should not interfere with the mood of the story. The main menu is a picture of a landscape from bird's-eye view, where different parts of the landscape correspond to different menu items, and every item provides a separate game (see Figure 5). If the mouse is placed above such an object of the screen, a frame shows that it is a valid selection.

In this program the tasks are games:

"*Find the opening!*" game

In this game a Landolt ring test can be conducted. The Landolt ring looks like a letter C. The task is to determine from different distances the opening direction of the Landolt-ring, which is rotated by the program. The user (teacher) can set the parameters: the size of the ring, its colour and texture, the colour of the background. One can run the test using the capital letter E instead of a Landolt ring. In this case one has to determine in which direction the openings of the fork show.

Figure 5: The main menu of our new multimedia software.

"*Black and white*" game

In this task the screen is divided into two parts. On the left side different objects can be seen, on the right side the inverses of the same objects. Task is to find the corresponding objects on the two sides.

"*Catch it!*" game

In this simple game the task is to catch one of the moving animals with the net.

"Recognize it!" game

This game has two versions. The first is the easier task. On the display the picture of an animal appears, and the child has to tell what he/she has seen. The pictures change at random. The picture disappears after a given time, and then one has to guess what one had seen, or one can make a new trial.

The second version is a more difficult form of the this game. As can be seen in Figure 6 there are three objects seen simultaneously. They have to be recognized one by one.

"*Small differences*" game

This is a computer variation of the well-known task to observe small differences. Figure 7 shows an example. The two pictures differ only in some slight details. One has to point with the mouse onto the differences observed. The drops in the upper right corner show how many differences have still to be found.

"Puzzle" game

In this game the picture has been subdivided into 3 x 3 rectangles. By the help of the mouse the place of two rectangles can be changed. The child has to re-create the original picture.

"Star" game

A further game is the Star-game, shown in Figure 8. Here the single stars have to be connected by a line to get a drawing of a familiar object. Compared to similar paper and pencil tasks the difference is that much more complicated arrangements of the stars can be used, because the star that is the next in the drawing changes its size periodically and the child has to see this movement.

"Football" game

One has to move the ball with the help of the mouse and get it into the goal. But one has to be careful not to hit the goalkeeper (the hedgehog). One can set the size of the ball, so that it should be easier to see

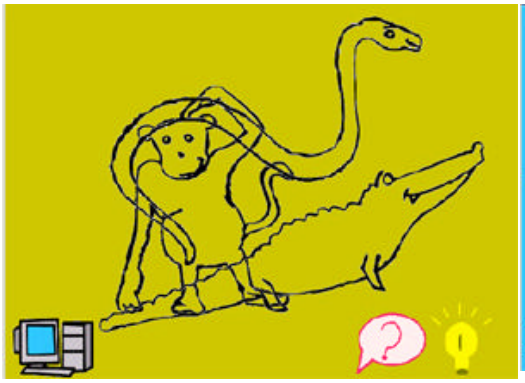

Figure 6: Recognize it game.

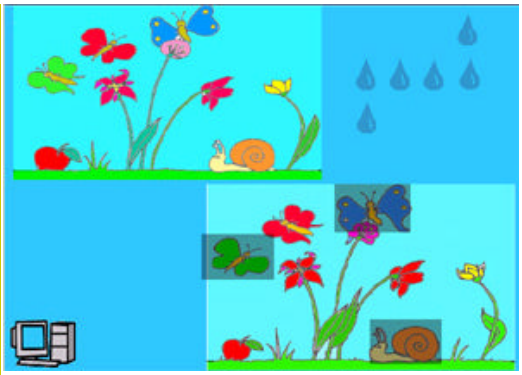

Figure 7: Small differences game.

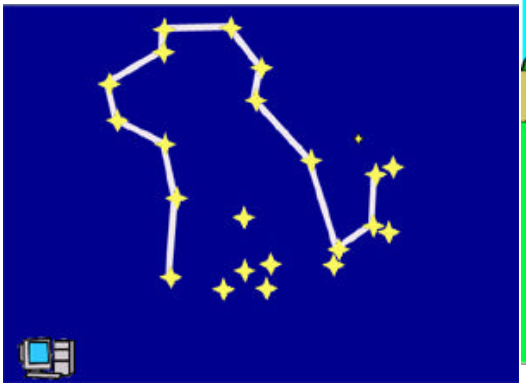

Figure 8: The Star game.

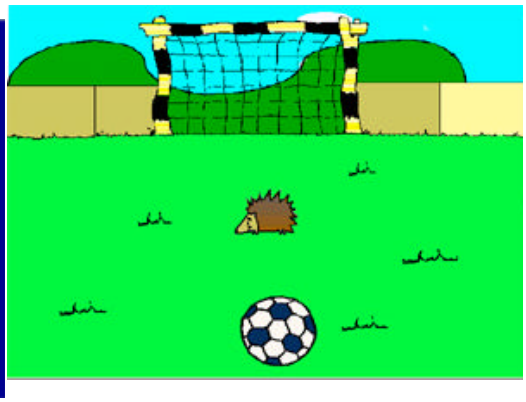

Figure 9: The Football Game.

it, this will, however, increase the difficulty to aim the direction. Figure 9 shows the arrangement of the screen.

Evaluation of the Programs

Because the rehabilitation of the patient can be seen only after several years, it is very difficult to evaluate the usefulness of such multimedia programs. To wait for these long-range effects would not be acceptable. However, the programs are the modern counterparts of old techniques, thus they can be compared with their traditional counterparts.

The effectiveness of the amblyopia treatment by one eye occlusion was proved in the medical literature a long time ago, and it has been shown that the most important healing agent is the forced use of the weak eye. If we can get the child interested in using the weak eye, we succeed.

To evaluate the usefulness of our programs, we designed a questionnaire and sent it to special schools together with the programs, asking them to test the programs and give their opinion on the usefulness by filling in the attached questionnaire.

Up to now eight groups have tested the programs and have sent back the filled in questionnaire. We have asked eight questions on the acceptance and usefulness of the programs, and requested to give the opinion of the teachers using a five step scale, where 1 was the lowest mark, and 5 the best. The questions, the average mark the teachers gave, together with the standard deviation of the marks is reproduced in Table 1.

Question	Average mark	Standard deviation
1. How well does the program help to ameliorate the visus of the children?	4.0	0.8
2. How well do the training and the games suit the children?	4.0	0.8
3. Is the wording understandable to the children?	4.4	0.5
4. Is the program motivating the children?	3.9	0.8
5. Are the pictures appealing to the children?	3.5	0.8
6. Is the tutorial character of the program adequate?	3.6	0.5
7. Does the use of the program attract the children?	3.7	0.8
8. Is the navigation system and the interactivity of the programs adequate.	3.8	0.5

Table 1. Evaluation of the feedback received from different groups.

As can be seen from this table the acceptance of the programs was very good and the children liked to use them (Question 1 and 2). This is the most important for training their eyes.

Teachers who grew up using the traditional paper-based educational materials appraised the tutorial character and the appeal of the pictures somewhat lower. This is partly due to the novel character of the pictures, and partly due to some changes made in the tutorial sequence of the single steps in the program. These questions will be discussed with the teachers in more detail and the necessary changes made in a second version of the programs.

The general comment was that the children enjoyed “playing” with the programs, thus they found the tasks they had to execute a game, not a burden. As mentioned this is the most important point in the use of the new medium to train the blunt eye of the child. In the questionnaire we have not asked about other

issues that were obvious: that the computer version avoided the soiling of the paper cards, their easy re-use, and their adaptability to the level of the bluntness of the eye (line width, contrast of the pictures, etc.).

The time since the production of the programs is still too short to be able to report on the long-range results one can achieve with their use, but we are confident that this can be proved, as from the ophthalmologic point of view there is no major difference between the multimedia and the traditional methods. One can just enumerate a number of advantages starting with higher motivation of the child and ending up with the adaptability to the individual requirements of the patient. We hope that in a follow up paper – to be prepared together with the teachers who use the programs – we will be able to concentrate on the ophthalmologic results too.

Conclusions

Multimedia can be an important tool to teach children. The teaching of handicapped children with multimedia tools is an important area of application. We have selected the area of producing multimedia games for partially sighted children, because here the multimedia games can be used very effectively. It is an important area of application. We have produced three programs for partially sighted children to improve their vision. These games can be used both in individual and small-group teaching. It can be given also into the hands of parents to use it with their children.

The computer can be used, with the help of appropriate software, in the therapy of amblyopia. We are convinced that such games can help the development of the visus of the children. We have first considered the needs and, after getting first reactions from the teachers, have developed the programs in such a form that they can be used effectively.

The programs can be downloaded from our server http://vision.vein.hu/mmvv (Lanyi, 2002). We would like to encourage other teachers who deal with partially sighted children to test them, and we would be very grateful to get further feedback on results obtained.

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Biographies

Dr. Cecília Sik-Lányi is associate professor at the University of Veszprém, Department of Image Processing and Neurocomputing. She studied Mathematics and Computer Science (M.S.) – József Attila University, Szeged, and teacher of mathematics (Berzsenyi Dániel Teacher Training College). She obtained the degree of Dr. Univ. at the University of Veszprém, Veszprém, Hungary in Physical-chemistry, and of PhD at the University of Veszprém, Hungary in Computer Science. She reads and leads laboratory studies on Multimedia and Virtual Reality. Her research area is in Multimedia and Virtual Reality in education and rehabilitation.

Dr. Zsuzsanna Lányi is Head of the Ophthalmologic Department of the Ferenc Csolnoky Hospital and works also at the county clinic of Veszprém. She has both a diploma for general medicine and ophthalmology. She deals with children's ophthalmology since 1988, and specialized in this subject.