Analysing the navigation of mentally impaired children in virtual environments

C Sik-Lányi[1], R Mátrai[2] and I Tarjányi[3]

Department of Image Processing and Neurocomputing, University of Pannonia,
Egyetem Street 10, Veszprém, HUNGARY

[1]*lanyi@almos.vein.hu*, [2]*ritka@vision.vein.hu*, [3]*istvan_tarjanyi@vipmail.hu*

www.vein.hu, www.knt.vein.hu, vision.vein.hu

ABSTRACT

In today's information society, computer users frequently need to seek for information on home pages as well as to select among software functions. A well-designed interface is essential in order to find everything necessary and meet the requirements of both the average user and users with special needs. Our project set out to discover where and with how much contrast objects should be placed on the screen in order to find everything easily. We examine what kind of characteristic searching routes can be found and whether we can find differences between the average user and mentally retarded user in navigation and everyday searching exercises.

1. INTRODUCTION

Numerous visual experiments have been carried out to discover how to organize objects and how to set up colours to help the process of searching. In the case of visual searching exercises, elements like orientation, colour, motion, size, shape, position of objects and of the background, density of objects (spatial frequency) could facilitate or hinder the search. During the past 25 years numerous visual search models have been produced, which dealt with the question of how humans are able to find objects, and tried to predict the results of visual search tasks. (Chen 1982, Mátrai et. al. 2005, Pomerantz and Pristach 1989, Sagi 1988, Treisman and Gelade 1980, Treisman and Gormican 1988, Wolfe 1994)

Visual search models distinguish two stages in searching. The first is a preattentive, largely parallel stage that processes information about basic visual features (e.g. colour, form, depth) across large portions of the visual field. Information processing results in the formation of feature maps in the brain. A subsequent limited-capacity stage follows in which other, more complex operations take place (e.g. face recognition, reading) over a limited portion of the visual field. (Treisman and Gelade 1980, Wolfe 1994).

An interesting question is how humans search for information on homepages among a lot of text, menus and pictures. Studies by Nielsen (2006) showed that users do not read but scan homepages: they scan the page and try to select information from it which can be useful for them. Nielsen's recent studies on eye-tracking discovered patterns in the way pages were scanned. Three types of web pages were examined. The first one was an "About Us"-page and was scanned in an L shape which flipped horizontally. On a product page on an e-commerce site, the scanning pattern resembled an F. Search engine results were scanned in an E shape.

In our current research we investigated whether similar shapes can be found for average and mentally retarded children in playful search tasks. This research was more complex than Nielsen's tests, because the found objects had to be clicked and the order of the perceived and clicked objects is not necessarily the same.

Nowadays interactive (dynamic) homepages (e.g. forms, web-shopping pages, on-line ticket ordering pages etc) are frequently used. In these one has not just to read, but has to click on some objects, in the correct order. We wanted to discover the sequence of the clicking in the various tasks. 15 mentally impaired and 50 average children took part in the research.

2. METHOD

In order to examine the visual search process several programs were developed, from which the tasks introduced in this article were also realized in a 3D environment. Effects of each visual feature on reaction time and searching routes can be described with a linear regression model in which the input variables are the visual properties and the response variable is the latency to click. Results will be evaluated with the help of this regression model. The following hypothesis will be tested:

- H1 hypothesis: Properties of objects (direction, colour, placement, etc.) have different effects on reaction time and searching route of mentally impaired users.
- H2 hypothesis: In 3D space reaction time is longer for the same search task and the visual properties of objects have different effects on reaction time and searching route.

2.1 Presentation of the software

In the first exercise the same object is shown four times on the screen in a row each time in one of four different orientations, facing to the left, to the right, up or down (Figure 1). In one worksheet only one figure appears. Orientation is generated randomly at the beginning of each trial. In the first part of the exercise figures facing to the left should be painted red while in the second part the ones facing to the right should be painted blue. On some of the trials none of the figures looks to the left and/or to the right.

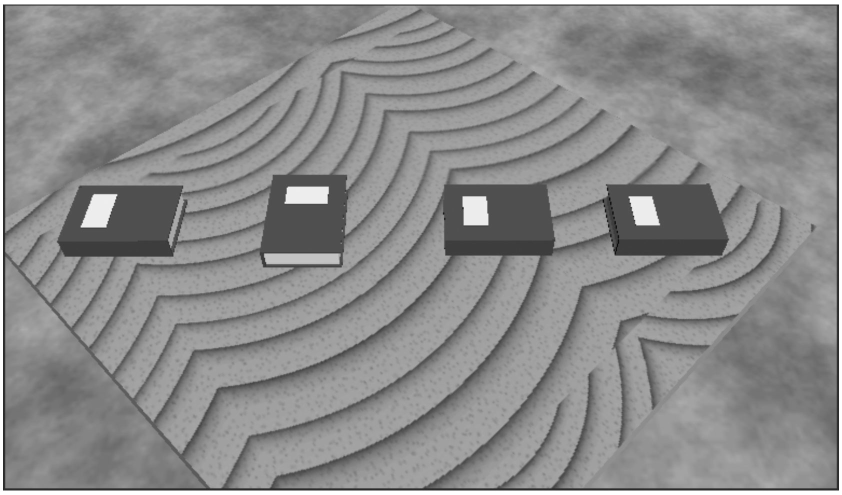

Figure 1. *A worksheet from the 3D-version where figures looking left should be found.*

Previous experiments found that if the object to be found is not present, searching time increases (Wolfe 1994). We expect similar results in the current test. As not only average children are involved in these examinations but also mentally retarded children, it was important to prepare simple exercises. We also compared the searching time for figures facing left and right in case there were more of one than the other; the order of clicking on them; and, in case the target figure was not displayed, the amount of time taken to realise this.

In the following task shapes (star, circle, square, etc.) were cut from a rectangle, and put next to the rectangle with some other similar shapes. The task was to put back the shapes. We examined whether position and form influenced the order in which shapes were chosen.

Several exercises were constructed to examine the visual search process when the target is the type of shape and the displayed objects are geometrical figures. Each worksheet has also been prepared in 3D form. We examined how results of searching depend on the contrast between foreground and background, and how they differ between special needs users and average users. We also examined whether some kind of order can be found in search routes or whether they are completely random, and also compared 3D and 2D tasks.

2.2 Participants

The programs have been tested in two primary schools where during computer aided and conductive lessons pupils could play with the program with the guidance of their teachers. One school was for mentally retarded children while the other was for average pupils.

2.3 Devices

Seventeen inch CRT-monitors were used in the school computer rooms. Teachers took care that the children did not bend too close to the monitor in order to maintain a focal distance of 60 cm. As understanding and remembering directions is often problematic for mentally impaired children we used a trick: on the top edges of each monitor the word LEFT or RIGHT indicates the directions accordingly. This helped them when completing the exercises involving differentiation of orientation.

3. RESULTS

In this research we intended to find the most salient properties of the object (placement, direction, etc.), which influenced the reaction time both for mentally impaired and average children. Since 3D displays are becoming more and more popular it was important to compare the reaction time of similar tasks in 2D and 3D. However there was additional information in the 3D tasks (spatial placement, highlights and shadows), which facilitated or hindered the navigation of the task, therefore it was necessary to compare the results of tasks in 2D and 3D.

3.1 The effect of object placement on navigation

In the first visual search experiment the relationship between placement of objects and order of clicks was examined. The first object was at the extreme left side and the fourth object was at the extreme right side of the display (see figure 1). The effect of reading direction had a significant effect on clicking. Generally the first clicked object was the first object, in other words the first object reached if scanning from left to right. The second clicked was the second object and so an. However, for the mentally impaired children the effect of the orientation was more significant than the position of the object. Since the orientation of the object is a random variable, results are presented separately for each orientation (left, right or up) of the object. Figure 2 shows the relative frequency of the first clicked object. Here the right answers are the first boxes, because the task was to click the objects, which were looking left.

In Figure 2 the first column on the left shows that the first click occurred on the first figure (from the left) in 68% of all tasks where the first figure faced towards the left. The second column shows that the first click occurred on the first figure in 30% of all tasks where the first figure faced right, etc. Since the task was to find figures facing to the left the correct answers are indicated by the first boxes. In this comparison it can be seen that the number of mistakes was lower for average children, and the effect of position was more significant than orientation of the object for mentally impaired children. The figure on the extreme left was clicked first even if it was in the wrong orientation.

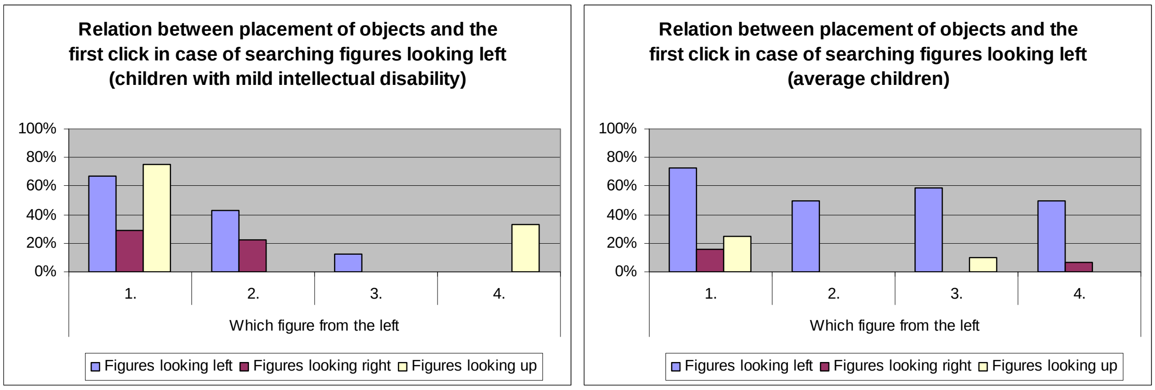

Figure 2. *First clicked objects where the task was to find figures facing left.*

In the second half of the game the task was to find objects which were facing to the right.

The effect of direction of reading is very significant for mentally impaired children. They made fewer errors (the right answers are indicated by the second column), but in the mentally impaired children the effect of solving the previous task (where they had to find objects facing left) has influenced the results. There are some cases where children clicked the objects facing left (Figure 3).

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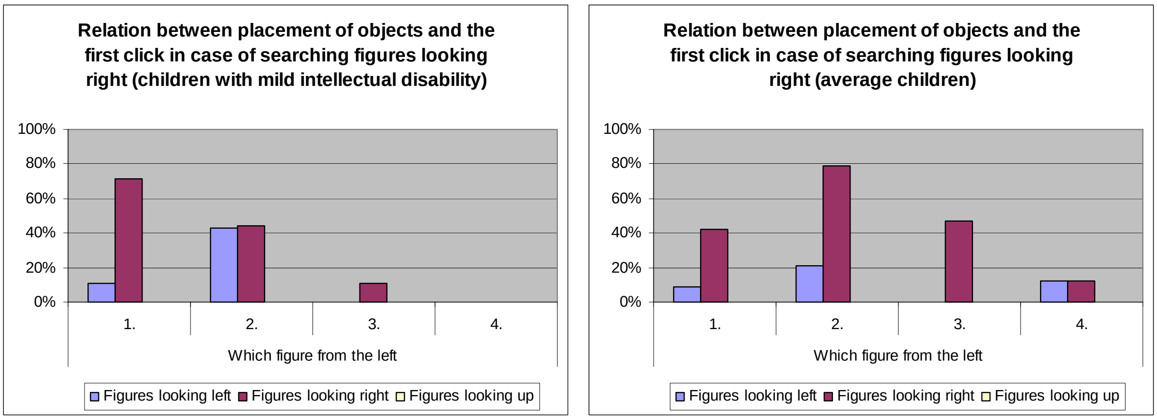

Figure 3. *First clicked objects where the task was to find figures facing right.*

3.2 Finding the right place for the shapes

In this task the order of selecting objects was examined. Figure 4 shows which figure was selected first.

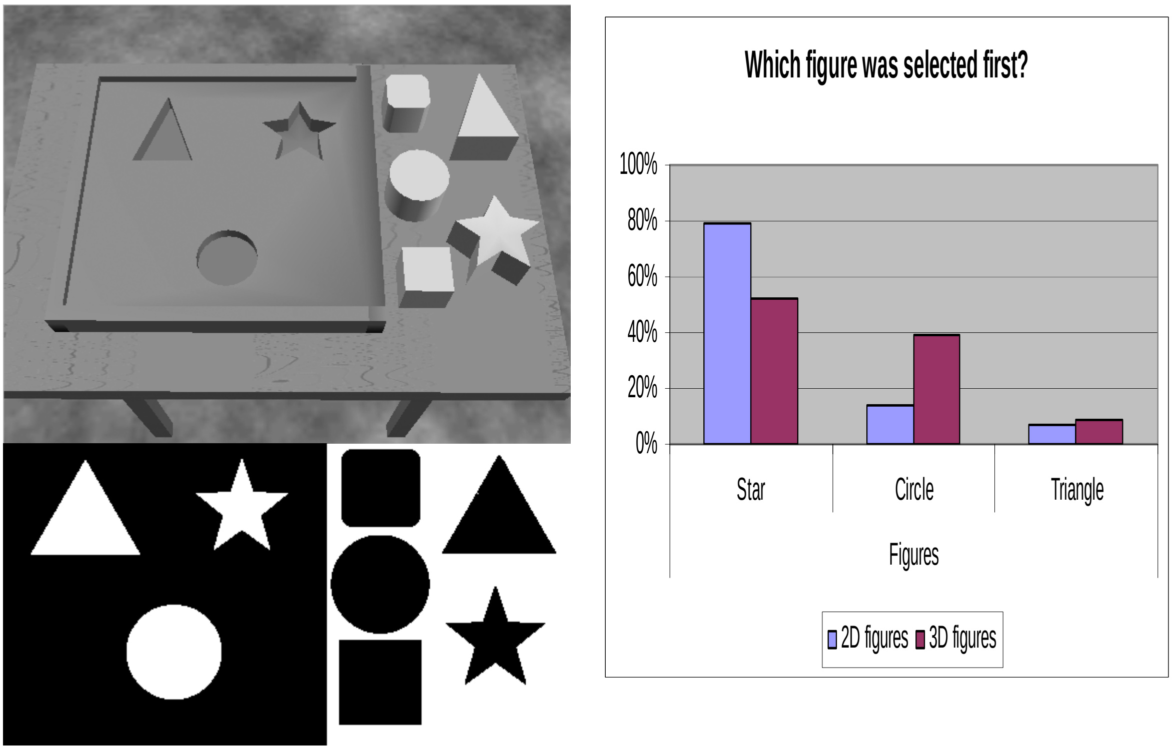

Figure 4. *Which figure was selected first?*

It is understandable that the first selected object was the star, because this object is very different from the other objects. However, it is very interesting that the triangle was selected by very few children as the first object as it is the next most different object after the star. The reason for this phenomenon might be the position of the objects: the triangle was on the right hand side, the circle on the left hand side, and children probably started from the left.

3.3 Finding geometrical shapes

This task was more difficult than those discussed previously. In this 2D and 3D worksheet children had to find geometrical shapes. The aims of this investigation were to find typical search routes, and to compare the reaction times and search routes in 2D and 3D tasks.

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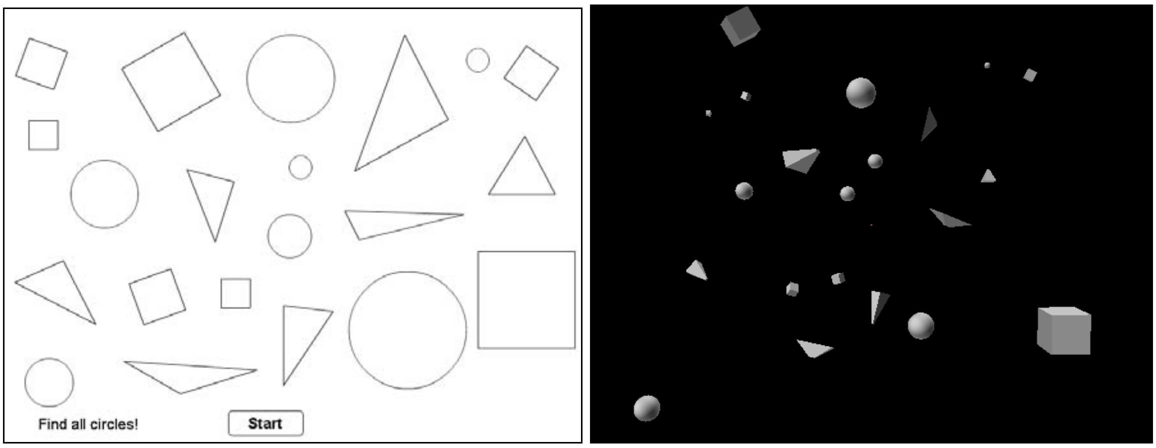

Figure 5. *Two similar tasks in 2D and 3D where circles/spheres had to be found.*

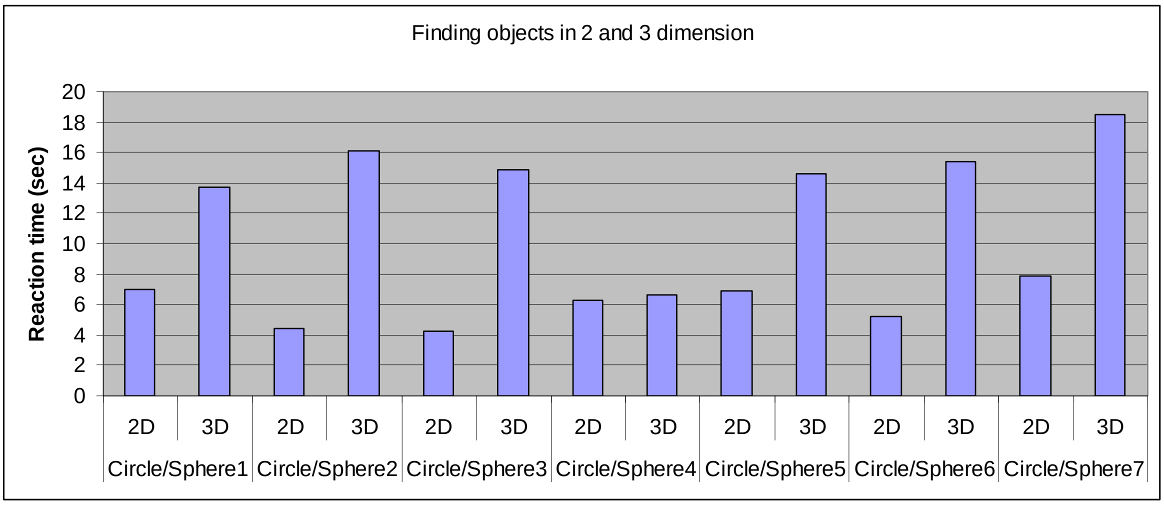

Figure 6. *Comparison of reaction times for the similar tasks in 2D and 3D.*

Figure 6 shows that the reaction times for the 3D tasks are higher than those for the 2D tasks. This may be because more visual features had to be processed in the three dimensional task.

Figure 7 shows two typical search routes in both tasks.

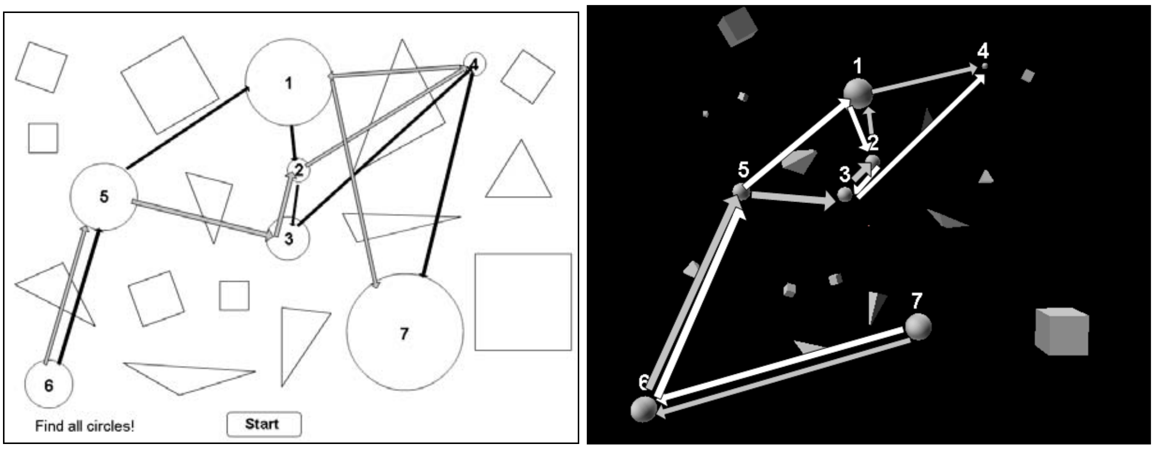

Figure 7. *Comparison of searching routes of the similar tasks in 2D and 3D. (Different colours of arrows show the alternative searching routes).*

The "left to right" direction of the search can be seen in all search routes. Since the *Start* button is at the bottom of the worksheet the direction of search is upwards. It is interesting that in the 2D task finding the 7th circle was the most difficult. This might be because it was near the bottom of the right hand side where, according to Nielson, people rarely look. It might be that after focusing on the small circles it could be more difficult to observe it because of its large size.

4. CONCLUSIONS

The position of figures is very important in navigation and finding objects. Generally this effect is more significant than the shape or direction of figures. The direction of navigation is usually the same as the reading direction, but this effect is more significant in mentally impaired children. In 3D navigation there are additional effects (lights, shadows, etc.), which usually make it more difficult to find objects.

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