A New Method for the Characterization of the Perspicuity of User Interfaces

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Abstract: This paper presents a new method for the characterization of the perspicuity of user interfaces based on users' navigation structures and reaction times. The user interface of a web page or software is good if users easily find information that they need. Therefore, it seems to be logical to give search tasks to the users and characterize the perspicuity of a user interface on the basis of the search time and navigation structure of the users. Experiments started with tasks where users did not have to read; they searched among 2D and 3D geometrical objects and among pictures. The experiment investigated which areas of the screen were preferred. These experiments were followed by tasks where the participant had to read as well. Here information was organized in columns because on web pages and news portals, the user is often confronted with layouts in columns and must search textual information ordered in columns. These tasks investigated how multi-column layout guides visual attention and how settings can help or disturb users to find information they need, settings such as the number of columns, target positions, word length, meaningful/meaningless context, colour of the fore- and background, size of the area which had to be scanned.

Keywords: web usability; user interface; navigation; navigation strategy; web page layout

1 Introduction

The importance of information communication via internet is nowadays undisputed. A web page should be well-organized and attractive so that users like to use it. Information seeking should not take a long time. The length of information seeking depends on the transparency of the web page. The appearance and usability of a web page affect users' perceptions, emotional reactions and behavioural intensions, which are controlled by cognitive processes. This paper deals with the subject of how cognitive processes influence our information seeking on various user interfaces, and which settings can result in a more transparent web page.

Many factors influence the transparency of a web page or software interface: the amount of information on the screen, organizing information, font size, background etc. [[1], [2], [3], [7], [15], [17], [18], [20], [21], [24]] All of these parameters provide the "overall picture" which the user sees on the screen.

Efficiency of search is influenced by several factors whose impacts are hard to measure. In the case of an information-seeking task on the interface of software or home page, the effect of several factors appears and affects click time. Numerous researches have dealt with the effect of each factor separately and altogether. In the international literature it seems when compiling experiments the effect of each factor or two or three factors joint effects are examined through deliberately simplified tasks and, as a result, conclusions are drawn on design user interfaces [[1], [15], [16], [17], [18], [19], [20], [22], [26]]. In these investigations usually one target should be found.

In order to analyse users' navigation structure, those search tasks are needed in which not only one but also more objects must be discovered on home pages or on the interface of software.

If the interface is perspicuous for the user, he/she will be able to follow the shortest route to click on targets; thus, his/her strategy is global. On a more crowded, disordered screen the strategy becomes local; thus, the user can not include the whole screen and must concentrate on only a part and click the nearest object after a target is found.

Analysing reaction times in function of the number of found targets is also important. If the interface is not perspicuous for the user, he/she needs more time to find after each target the next one; therefore, reaction times can be approached by exponential trend; opposite to a perspicuous interface, where this trend is linear.

The aim of the current research is to characterize the efficiency of user interfaces.

The second section introduces the cognitive process of visual search and text reading. The third describes the method of measuring transparency of a user interface. The forth section presents the information seeking tasks done by the participants. The fifth section introduces the participants of our experiment and the devices which were used during testing. The sixth section shows the results of the reaction times analysis and navigation strategies separately, and finally, the most important findings are summarized in the "Discussion" section and conclusions drawn in the "Conclusion" section.

2 Cognitive Background

2.1 The Process of Visual Search

When we look at a screen, we are confronted with a vast number of visual stimuli. We may only browse the screen, and we may seek information. In all cases we map the screen with little eye-movements called saccades; fixation duration between the saccades is approximately 200-250 ms. Saccades take on average 30 ms.

We often have to search for objects, icons or text information on the screen. This process begins with a visual search which can be divided into two parts: first, visual information from the whole screen is appraised and a "map" generated from the basic visual features (e.g. colour, form, etc.); then in the second stage a small part of this information is processed in detail. Object recognition and reading occur in the second stage [[6], [20], [23], [26]]. Visual attention allows the selection of the small amount of available visual information that is processed [[26]].

The attentional area changes with every saccade; the size of this area change depends on the actual task (e.g., the size of the object being searched for). Signal processing in this area is usually more detailed in the centre of it. But, in some cases, the centre of this area is leaky; thus, we do not see the centre of the area where we fixate. The attentional area can consist of a more disjunct area. [[1]; [6]; [8]; [9]; [10]; [11]; [12]; [20]; [26]]

How does visual attention operate? Many concepts have been put forward for characterizing visual attention. According to William James, visual attention looks like a spotlight with which a small area of a dark stage is illuminated: perception is more precise or faster in the area to which we pay attention (the area of the field of vision which is "illuminated"). This area is the limited part of the field of view which is processed in detail by the brain [[8]].

The area of attentional focus is not static; it can be smaller or larger depending on the actual task [[10]]. The efficiency of processing in the attention area is not uniform; it decreases by moving off the central point [[11]]. However, it was found in certain tasks that the centre of the attention area can be "holed" as well, as if it were ring-shaped [[5]]. Moreover, some researches have highlighted the discontinuity of the spatial attention. The attention area can be made up of more areas which are not connected with each other [[9]].

It is important to note that we are able to fix on a given point but pay attention to another point of the field of view, which means that the attention area and the area around the fixation point are not definitely the same. Helmholz took note of this phenomenon for the first time.

Several factors influence visual search: the visual hierarchy of the screen, the properties of targets and distracters, highlighting, colours etc. [[1], [2], [7], [18], [22], [24]]. Analysing the navigation strategy of users can tell us which objects can (and cannot) be observed easily and how information seeking tasks can be promoted with the properties of the objects.

2.2 The Process of Reading

Reading can occur only in the attention area. During reading, the eyes move along each line with fine eyeball movements called saccadic movements, and between the saccades the eyes make fixation pauses. The eye of a fluent reader of English text jumps 7-9 characters in one saccade. In the case of longer words, more fixations occur within each word. Furthermore, fixation duration and the number of saccades in the reverse direction increase, and recognition also becomes more difficult [[12], [19]].

Reading speed depends on text difficulty as well. The more often we use a word, the more familiar the word is, the quicker it can be recognised. This is explained by the "mental dictionary" part of memory in which words are stored. The more often that the memory area is activated within the dictionary, the quicker a word can be reached [[6], [25]].

Reading speed can be influenced by the colour of the background as well. If a text is written on dark background with light letters the pupil of the eye expands; therefore, the resolution of the eye become worse, which makes reading more difficult [[1]].

3 Method

We assume that the task of the user when navigating a webpage is to find specific information about a pre-defined subject. In this section, we introduce some graph representation methods that can be used to characterize the behavior of users while completing such tasks. In the test software several targets should be found in order to make the analysis of the navigation structures possible.

3.1 Determine Navigation Map

First, a picture is needed of the interface. The clicking sequences of every user can be drawn; this is called the *navigation route*.

The users' clicking sequences can be summarized in frequency tables which show how many users chose target *j* after target *i*. (Targets should be numbered.) A similar table should calculate with relative frequency values.

The clicking sequences of all users can be drawn in one graph, which is called a *navigation graph*. The navigation graph is a directed, weighted graph. Arrows show the clicking sequences; the weight of an arrow is the relative frequency value which shows which percent of users chose target j after target i.

If there were no relation between targets position and clicking sequences (this is called *independent case*), then in the graph there are arrows between all targets and with equal weights, which are equal to $1/n$ where n is the number of targets. But if the graph is very different from the independent case, it shows that there is a structure to the navigation of users.

The navigation graph may contain edges whose weight is not greater than $1/n$; these can be omitted from the graph. The navigation graph without any non-significant edges is called the *navigation structure*.

The next step is to determine the most probably clicking sequence. In some cases this can be determine from the frequency table, but in other cases it is not clear. With Thurstone's scale transformation, a preference scale can be made from the clicking sequences.

The most probable clicking sequence should be indicated on the navigation structure, which is now called *navigation map*.

3.2 Determining the Navigation Strategy

From navigation map, the navigation strategy of users can be determined. If the user could perceives the task, he/she clicks on targets on the shortest navigation route, and thus, the navigation of the user will be *global*. If the interface is not so perspicuous, the user strategy becomes *local*, and thus, he/she clicks on the nearest object after a found one. He/she can concentrate on a smaller part of the screen and find every target there; after that he/she pays attention to another part of the screen.

If the interface layout is multi-column, then a *column-by-column* strategy can also be observed; this means that the user finds targets in the first column, and after that continues searching in the next column, etc. The moving directions within a column are ignored.

If the strategy is not global,local or column-by-column, then it is called *ad-hoc*.

The navigation strategy most similar to the user strategy should be determined. For this, a so-called *identity index* was introduced; this shows how similar user strategy is to each navigation strategy. The value of the identity index is equal to 1 if the two navigation routes are the same, and it is equal to 0 if no similarity can be found between the two routes. First, the global, local and column-by-column strategy should be determined for the task, which will be a navigation route, and this route should be compared with the user navigation route. One should calculate how many "parts of routes" there are, and thus, how many arrows are the same between the two routes. This value should be divided by *n-1* where *n* is the number of targets; in other words, this value should be divided by the number of arrows in a route.

The formula of this index can be read in an earlier publication [[17]].

3.3 Analysing Click Times (Reaction Times)

Click times can be illustrated in the function of the number of found targets. It can be examined whether a linear or exponential trend fits better to the data. If the interface is perspicuous for the user, he/she discovers targets easily, and therefore discovering targets after each other takes approximately the same time. But, if the trend is exponential, it shows that users need more and more time to discover the next target, which indicate a more crowded, disordered screen.

3.4 Assumptions

We assumed that if there are global or local strategies, the navigation route and also the solution time become shorter. In the case of multi-column layout worksheets, we also assumed that the value of the parameters influence the solution time. In detail:

1 We assumed that meaningless context generates a longer solution time, because it makes the recognition of non-target words more difficult. If non-targets are also meaningful words, than users can recognize them in a shorter time (because their mental dictionary contains that word), and therefore they can scan the screen faster.

2 We assumed that the longer the words are, the longer the time needed to solve the task, because longer words need a greater attention area in order to read them.

3 We assumed that the darker the background, the longer the solution time will become, because the resolution of the eye becomes worse if a background is dark.

4 We assumed that the smaller the area of screen scanned, the shorter the solution time will be, because in this case, the route of eyes movements becomes shorter.

5 Finally, we analysed whether the value of the parameters influence navigation strategy and the length of navigation route.

The categorical regression model was used for discovering relations between the factors and reaction times/navigation strategies. To decide which factor affects the process of search the most and which factor affects it the least, we applied the decision tree method.

4 Test Software

This method was tested in several user interfaces.

4.1 Searching Geometrical Forms (2D, 3D)

First, a worksheet was given to the users in which it was not necessary to read; here the effect of the position and properties of objects on click times and navigation strategies was investigated. Some results of these investigations have already been published ([[13], [14], [15], [16], [17]]), but not with the point of view of perspicuity. Therefore, these tasks are mentioned in this paper as well. First, geometrical forms were placed on the screen and the task was to find all occurrences of a particular shape. Similar tasks were made with 3D-objects.

4.2 Searching in Picture

Two tasks followed these investigations where users had to search objects in a picture. Here it was examined whether the users' search can be promoted if the target is conceptually related to the background. In the first case, birds had to be found in a forest; in the second task, fish needed to be found in water and also in unusual places (e.g., in a tree, in a cloud, etc.).

4.3 Searching on Multi-Column Textual Pages

The program consisted of 5 different worksheets. In each sheet, depending on the number of lines and columns, 48-50 words of the same length appeared in columns in Courier New CE font. Their font style was bold. The target word was embedded ten times, and their positions were randomly determined. In the first two worksheets meaningful target words had to be found among meaningless words of 5 or 8 characters. In the other four worksheets both non-target and target words were meaningful, and words consisted of 3, 5, or 8 characters.

Every worksheet was repeated with 5 different font colour/background colour settings: black, dark blue and red background with white letters; white and light greenish background with black letters. Experiments were carried out on calibrated CRT-monitors. Colour differences were measured in CIELAB units, and Michaelson contrasts were calculated. These metrics are usually used in measuring colour and contrast differences [[4]]. The l^*, a^* and b^* values of colours and colour difference values are shown in **Table 1**.

Each of these 25 worksheets was presented in three different layouts. In the first layout, words appeared in 4 columns with 30pt font size, in the second one in 6 columns with 20pt font size, and in the third one in 10 columns with 12pt font size. Participants had to solve each worksheet 10 times.

Table 1

*L**, *a** and *b** values of background colours, Michaelson-contrasts and colour difference values between the fore- and background. *L**, *a** and *b** values foreground were the following: *L**=95.7, *a**=-0.5, *b**=2.3 if the letters were white; and *L**=1.2, *a**=-0.3, *b**=0.2 if the letters were black.

Backgr.	foregr.	Background			Michaelson contrast	ΔE*ab
colours		L*	a*	b*		
dark	white	1.2	-0.3	0.2	0.98	94.52
dark	white	20	42	-76	0.65	116.91
red	white	50	69	48	0.31	94.91
white	dark	95.7	-0.5	2.3	-0.98	94.52
light greenish	dark	91	-46	22	-0.97	103.09

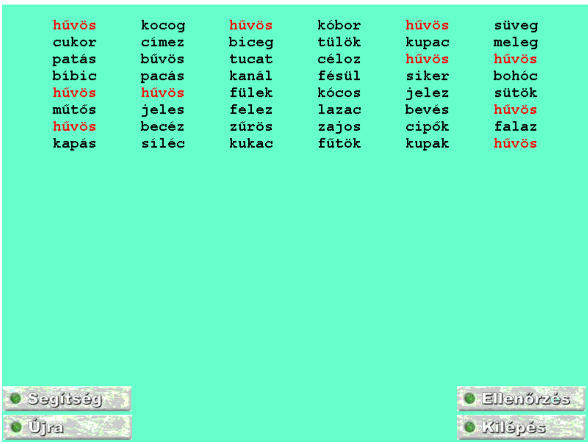

Figure 1

A worksheet in 8x6 layout with light greenish background

4.4 Searching in Web Pages

Following our experiments on multi-column textual pages, we continued our investigations with web pages.

The task was to find all occurrences of a given word on a home page. For this task, screen shots were made of 3 home pages, and target words were selected. These were words which occurred several times in the pages.

The number of target words in the pages was 7, 19 and 20. The page with 7 target words presented some products (decoration columns). The text was organized in 2 columns in the left half of the screen (menu and body) and on the bottom area; on the right side there was a picture showing the products. The page with 20 target words promoted some products of a department store. The page consisted of a menu on the left and a body in which there was a short introduction of the store. After that, 3 kinds of products were introduced with a photo of them. In a 3-column news portal page, 19 words had to be found, where only hyperlinks were organized by channels.

5 Participants, Devices

For every worksheet, 150 university students aged between 20-24, 55 secondary grammar students aged between 13-15, and 45 children with mild intellectual disabilities took part in the experiments, expect for a task on worksheets with multi-column layout; on this task, 123 university students aged between 20-24 were involved, and children with mild intellectual disabilities did not participated in these investigations because it was too difficult for them. The worksheets were displayed on 17’’ cathode ray tube (CRT) monitors, and the viewing distance was approximately 60 cm. Users who participated in the experiments could use the mouse without any difficulties.

6 Results

6.1 Searching Geometrical Forms (2D, 3D)

A previous study [[15]] had shown that “on an ordered page which contains little information, navigation strategies of normal users and those with intellectual disabilities corresponds to the global strategy”; furthermore, “on a more crowded and disordered screen less organised sequences were observed only in normal users, and no discernible patterns were observed in users with intellectual disabilities”.

Analysing click times in function of number of found targets showed that in the case of normal users, the data fits to a linear; R^2 values are above 0,97. This means that, despite the fact that their strategy was in some cases not global but local, it was not difficult for them to discover new and emerging targets. For children with mild intellectual disabilities, this linearity breaks after the 5^{th} found object, and only the exponential trend fits to the data, as is shown in **Figure 2**. This means that after the 5^{th} object, it was more and more difficult to discover the targets.

Searching among 3D-objects gave similar results, but click times were longer.

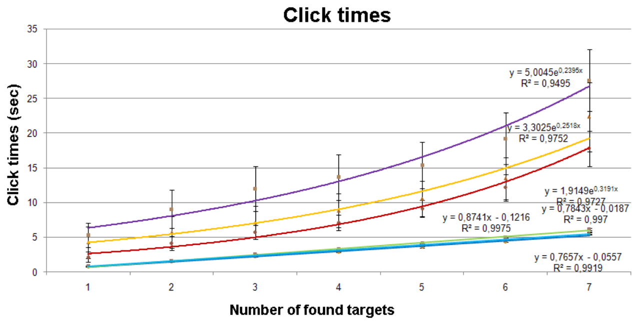

Figure 2

Click times in function of number of found targets in the case of searching among 2D-forms. The data of average users can be approached by linear trend; data of children with mild intellectual disabilities can be approached by exponential trend; here linearity breaks after the 5th found target.

6.2 Searching in Picture

In the case of finding birds in a forest, the navigation strategy of average users was ad-hoc, while the navigation strategy of children with mild intellectual disabilities was local. It was interesting that by analysing reaction times, the linearity usually breaks after the 4th or 5th object for children with mild intellectual disabilities; in this case linear trend gave the best approach for the whole task, where 9 targets should be discovered. Similar results were found in the other worksheet, where fish had to be discovered; here the ad-hoc strategy dominated for all groups, but linear trend could fit the data till the 8th found target. This means that if the background conceptually relates to the targets, then it improves the navigation of all users, but mainly of children with mild intellectual disabilities.

6.3 Searching on Multi-Column Textual Pages

6.3.1 Results of Decision Tree

There was the highest significance level (the closest fit to the model) if the grouping variable was the number of columns. It was followed by the variable which showed whether the context was meaningful or not. The variable that gave the least good fit was word length.

6.3.2 Analysing Reaction Times

The adjusted R^2 value of the categorical regression model was 0.363, which shows that the model explains a significant amount of the observed variance. All variables had significant values.

The average solving time was 15.1 sec (std. err. 0.06). The solving time was 16.3 sec in layout 5x10, 14.5 sec in layout 12x4 and 13.3 sec in layout 8x6. Searching among the small letters and 10 columns was much more difficult for the users than in the other two layouts. In this case users had to search in 10 “smaller parts” of the screen – not only in 6 or 4 – and this, as well as smaller font size, might have caused longer solving times. However, it is also more difficult to search for the target if words cover the whole screen, which corresponds to our assumption: searching became more difficult if a larger area had to be scanned. Searching for words in layout 8x6 was the easiest, where the letters were not too small, nor did the words cover the whole screen.

In the case of searching among 3-letter words, the mean solving time was under the average solving time; only 14.5 sec was needed. In worksheets which contained 8-letter words the mean solving time was 15 sec, and it was 15.4 sec in worksheets with 5-letter words. It was surprising that we got the longest solving time in worksheets where the words consisted of 5 letters, and not 8 letters. Words which contain 8 letters have more characteristics and therefore could be found faster.

A meaningless context made the users’ search more difficult; 16.4 sec was needed with those worksheets, and only 14.2 sec in the case of meaningful distracters. The meaningless context troubled the users, as we had assumed, because those words did not exist in the mental dictionary, and therefore it took more time to recognize them.

Foreground and background colours also influenced solving times. White letters on a black background caused the longest solving time, 16.2 sec; while the light greenish background with black letters gave the best results, 13.8 sec. No difference was found between the average solving times in the case of a dark blue background and in the case of a white background (15.4 sec). Worksheets with a red background needed 14.7 sec to solve.

The users solved those tasks the quickest where the settings were the following: a layout with 8 rows and 6 columns, words with 3 letters, a meaningful context, and a light greenish background with dark font colour. The average solving time was 12.4 sec with the best settings, and 18.4 sec with the worst settings, which is approximately 50% worse compared to the case of the best settings.

6.3.3 Analysing Navigation Strategies

In 17% of cases users followed the global strategy, and solving time in these cases was only 14.4 sec. The local strategy can be observed in 34% of cases, and average solving time was 15 sec. The “column-by-column” strategy was the most frequent strategy; it occurred in 43% of the cases, and the solving time was 16 sec. The ad-hoc strategy occurred in only 6% of the cases, and the average solving time was 17.8 sec.

Great differences were found in solving times and in strategies if we compare these results in the cases of the best and worst settings. The global strategy occurred in 18% of the cases in the case of the best settings, and in only 9% of cases in the case of the worst settings, meaning only half the times. This proportion can be observed with the ad-hoc strategy, but inversely. It occurred in 4% of the cases in the case of the best settings, and two times more frequently, in 8% in case of the worst settings. The local strategy was followed in 37% of the cases in the case of both settings. The column-by-column strategy dominated in every case; it occurred in 41% of the cases in the case of the best and 46% in the case of the worst settings.

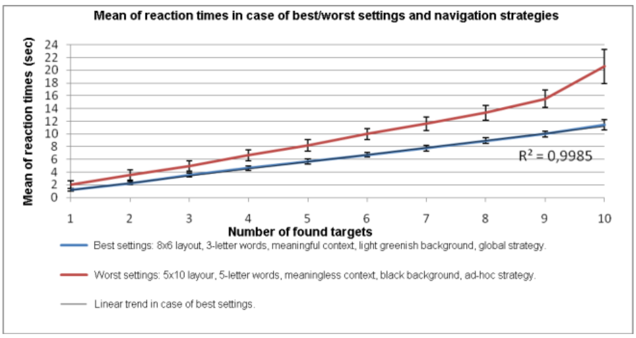

Figure 3
Reaction times (click times) in case of worst/best settings and strategies

The shortest solving times were measured in those cases in which the parameters were set to the best values and users followed the global strategy: 11.7 sec. The longest solving time was caused by those cases in which the parameters were set to the worst values and users followed the ad-hoc strategy: 21.4 sec, which is almost two times longer than in the best case. The confidence interval is also greater, which shows greater uncertainty in click times as well. Differences could be observed even by the click time on the target found for the first time, as is shown in Figure 2. In the case of the best settings, reaction times could be approached with linear trend up to the 10^{th} object, and in the case of the worst settings, up to the 9^{th} object as well. Linearity did not break after the 7^{th} object as in previous experiments; this means that users could perceive this task easier, and consequently, multi-column layout promoted users search.

6.4 Searching in Web Pages

On the web page which contained 7 targets, the global searching strategy was dominant with both groups. 80% of the normal users found the target on the top of the middle column, and after that the target in the menu. This proportion is 50% by users with mild intellectual disabilities. Only in this worksheet, reaction times of users with mild intellectual disabilities could be approached with linear trend even to the 7th object as well. The reason for this refers to a well-structured layout by which users could easily perceive the task.

Figures 2 and 3 show the navigation map on the page of the department store. 22% of normal users started from the menu on the left; 36% of them started from the first paragraph of the body, going from the top to bottom, and after that clicked on the targets in the 3 column in the bottom area. 62% of users with mild intellectual disabilities started from the menu, and only 21% started from the first paragraph. Among the columns, 70% of normal users and 49% of users with mild intellectual disabilities navigated from left to right. Navigation from right to left occurred only in approximately 10% of both target groups. In other cases navigation among the columns was unordered, or it was interrupted by the targets on the top of the screen. Local strategy dominated in the case of average users, and ad-hoc strategy in the case of children with mild intellectual disabilities. For average users, reaction times could be approached by linear trend to the first 7 target, and after that exponential trend could fit to the data. For children with mild intellectual disabilities, this linearity broke after the 5th found target.

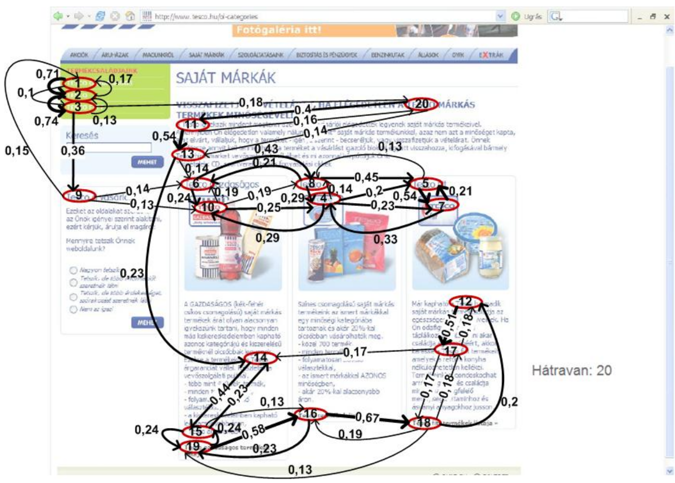

Figure 4
Navigation map on a home page by normal users

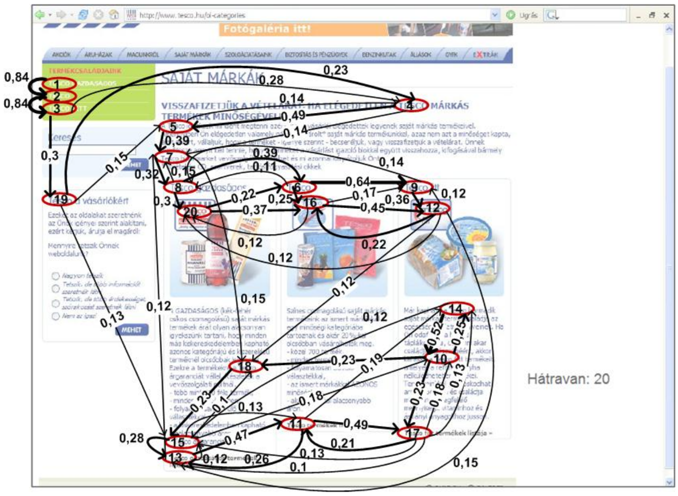

Figure 5
Navigation map on a home page by children with mild intellectual disabilities

In the case of the 3-column news portal page, where 19 words had to be discovered, reaction times could be approached with linear trend only till the 5th object for users with mild intellectual disabilities, and till the 10th object for normal users. This means that the multi-column layout promotes user search, and therefore it is recommended to use multi-column layout on home pages.

7 Discussion

This paper examines how perspicuity of user interface of a web page or a software can be characterized. The method is based on the idea that information seeking tasks should give to the users and their navigation strategies and click times refer to the perspicuity of the user interface.

In order to determine users' navigation strategy, a navigation map should be determined which contains navigation routes of all users and the most probable clicking sequence. An identity index was introduced in order to determine how similar are users' navigation routes to any kind of searching strategy.

Analysing click time in the function of the number of found targets is also important. If the trend is linear, it means that users can discover targets easy; if the linearity breaks and only an exponential trend fits the data, it means that the task became more difficult after any found targets. If the linearity breaks before the 7th found target by normal users (or before the 5th found target by children with mild intellectual disabilities, if the web page or software may be used by them as well), it is recommended to redesign the user interface.

The effect of multi-column layout on search time and navigation strategy was also investigated with several parameters, such as number of columns, word length, meaningful/meaningless context, and varied foreground and background colours.

The number of columns had the greatest effect on the solving time and on the strategy as well. Users could find targets in the layout with 8 rows and 6 columns the quickest, where the font size was 20 pt, presumably because in those worksheets only a small part of the screen had to be scanned. However, the solving time was the longest when this "window" was much smaller. Also, when words were placed in 5 rows and 10 columns with 12 pt font size, solving times increased. In our opinion the smaller font size made the task more difficult. When the layout covered the whole screen (12 rows, 4 columns, font size: 30 pt), the solving time was a little bit longer than in the case of the layout with 8 rows and 6 columns, presumably because users had difficulties looking through the whole screen crowded with words. In an earlier study [[15]], similar results were found with a crowded screen.

Solving time can be influenced by choice of foreground and background colour. It is not recommended to choose a black background, because in this case the pupil expands and the resolution of the eye decreases, which makes reading more difficult. However, no difference was found in solution time between a dark blue and a white background, which was with 5% shorter than in the case of the dark background. The red background made searching quicker; the difference is 10% as compared to the dark one. A light green background showed the best results, and in this case solution times were with 15% shorter than in case of the black background. Presumably, these colours promote the users' work.

Searching tasks become more difficult if users have to search among meaningless words. This phenomenon may be explained by the mental dictionary in our memory, which develops over the course of our life. The more often a word is used, the quicker recognition will be. Consequently, we have a more difficult task with meaningless words.

Word lengths influenced solving time only to a lesser degree. Although longer solving times were found for longer words, the difference was not considerable. However, it should be noted that the length of words was 3, 5 or 8 characters. When fluent readers are reading, the eyes move 7-9 characters in one saccade. Usually one fixation was enough to read each word.

Analysing click times on navigation tasks showed that users clicked on the first 9 objects with constant velocity. They need more time only after the 9^{th} object to find the last target. However, in a previous study it was found that click times can be approached with a linear trend if the number of targets is not greater than seven. The "breaking" always occurred after the 9^{th} object, independently from the settings. This means that a multi-column layout promotes user search. In some cases, where the user's strategy followed the global strategy, this "breaking" disappeared and the 10^{th} click time also fits to the linear trend.

Conclusions

A new method was introduced with which the perspicuity of user interfaces can be characterized. The method was tested on different kinds of user interfaces. Navigation strategies and reaction times were analysed.

Reaction times are linear functions of the number of the targets if the number of target is between 7 and 10 in the case of average users and between 4 and 5 in case of users with mild intellectual disabilities. If the background conceptually relates to the targets, then the reaction times of users with mild intellectual disabilities can be approached by linear trend in the case of 7-8 targets; thus, not only their navigation can be improved but also their reaction times can be decreased. In the case of textual search tasks, a multi-column layout promotes user navigation. In this case, reaction times can be approached by linear trend if the number of the targets is not greater than 9.

Multi-column layouts promote user search, and therefore it is recommended to organize texts and links in columns on a web page. Results also showed that it is better to display information in a smaller "window" which can be easily scanned, and not to cover the whole screen with text of a larger font size. The position of targets played an important role in finding them.

A dark background makes reading more difficult, and therefore it is not recommended to choose dark colours for the background. However, we did not get the best results in the case of a white background. The shortest solution time was measured with the light greenish background, and a little bit longer with the red one.

Searching among meaningless words needed more time. This phenomenon may occur if a home page contains a lot of unknown words, and therefore on web pages and news portals, where the user normally has to search through a greater amount of information, it is worth choosing words which are presumably known for most of the users.

With word length varying from 3-8 characters, longer words were found to have greater solving times, but this difference is not significant and routes are also not significantly different.

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