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Improving visual search in instruction manuals using pictograms*

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ABSTRACT
Instruction manuals provide important messages about the proper use of a product. They should communicate in such a way that they facilitate users' searches for specific information. Despite the increasing research interest in visual search, there is a lack of empirical knowledge concerning the role of pictograms in search performance during the browsing of a manual's pages. This study investigates how the inclusion of pictograms improves the search for the target information. Furthermore, it examines whether this search process is influenced by the visual similarity between the pictograms and the searched for information. On the basis of eye-tracking measurements, as objective indicators of the participants' visual attention, it was found that pictograms can be a useful element of search strategy. Another interesting finding was that boldface highlighting is a more effective method for improving user experience in information seeking, rather than the similarity between the pictorial and adjacent textual information. Implications for designing effective user manuals are discussed.

Practitioner Summary: Users often view instruction manuals with the aim of finding specific information. We used eye-tracking technology to examine different manual pages in order to improve the user's visual search for target information. The results indicate that the use of pictograms and bold highlighting of relevant information facilitate the search process.

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1. Introduction

One of the main purposes of instruction manuals is providing information to users in order to enhance their experience with the product (Celuch, Lust, and Showers 1995). Given that different users have different approaches to using manuals (Wogalter, Barlow, and Murphy 1995), special care should be taken in designing these documents. Even though recent research on the topic of how users read the manuals is quite limited, there are some empirical implications for making user-friendly instructions (Mayer and Moreno 1998, 2002; van der Meij 2008; Mertens et al. 2012). A basic requirement for effectiveness in graphic design of any kind of manual instruction is the clarity of the textual content. A well-structured text allows the user to quickly execute the instructions with a smaller error rate (Mertens et al. 2012). As suggested by some researchers (van der Meij 2008), the minimalist approach may also be helpful in designing the instructions. Another important consideration is the simplicity of the search processes for information that is relevant to the users. Most empirically supported principles for designing instructional messages were brought out by Mayer and Moreno. They suggest that information presentation is more effective when using two modes (words and pictures) rather than one (Mayer and Moreno 1998, 2002). This notion is called the multimedia effect. It is based on the finding that people learn new information more deeply from words and images than solely from words. The positive influence of the text-picture combinations was also reported in studies focused on students' visual attention during a lesson (Yang et al. 2013), as well as on reading comprehension, and learning (Mason, Tornatora, and Pluchino 2013). While combining textual with pictorial elements, it is important to use the kind of pictorial representation styles which appropriately complement the textual content, in order to avoid vagueness of the presented message (Bateman et al. 2001). While there is a lack of literature addressing the topic of picture superiority in instruction manuals, many researchers reported on benefits of including pictures in

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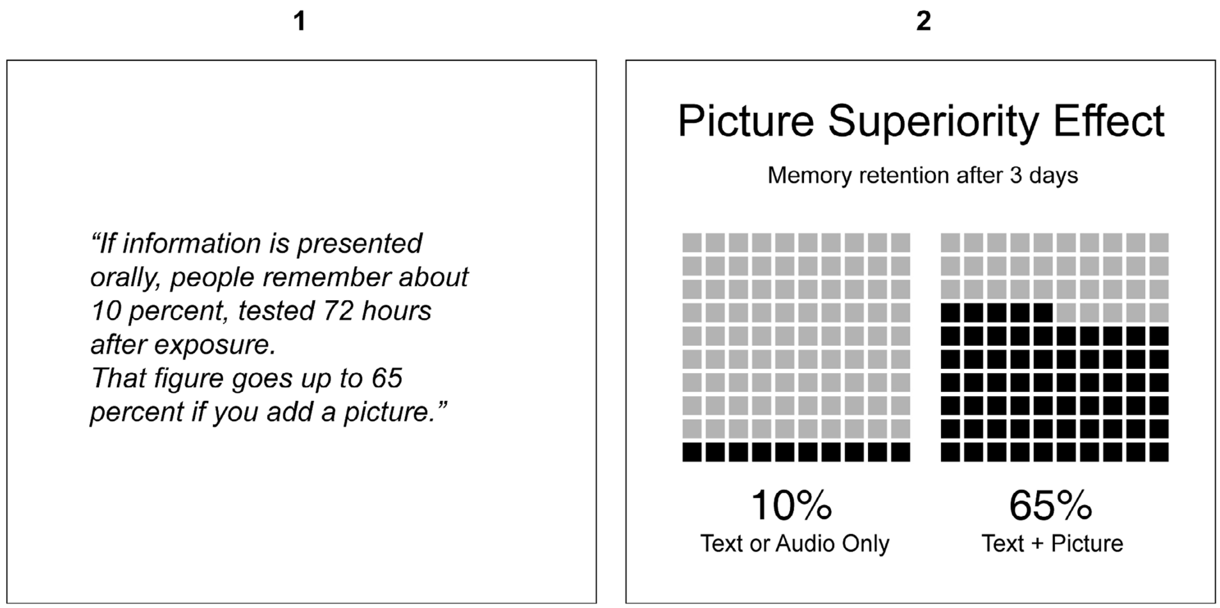

Figure 1. An example of the picture superiority effect; 1 – textual description according to Medina (2008, 234), 2 – graphical description according to Krum (2013). Based on research, graphical description should enhance the remembering of information about the power of the picture superiority effect.

other forms of visual display, such as websites. For example, the findings of a study focused on users' interaction with websites (Hong, Thong, and Tam 2004) support the idea that the combination of text and images outperform the text-only presentation. The inclusion of images led to a shorter information search time and a positive attitude towards using the website.

The positive impact of the text-picture integration could be achieved by including pictograms in manuals, especially in those which consist of a large amount of text. Some previous studies (Laughery and Young 1991; Laughery et al. 1993; Davies et al. 1998) have demonstrated the impact of including pictograms on the noticeability of the information placed in their proximity. For example, in investigating the memorability of warnings in instruction manuals, it was found that the use of pictorials enhances recall of the warning content (Young and Wogalter 1988, 1990). The positive effect of pictograms could be explained by the picture superiority effect (Figure 1). According to this effect, pictures tend to be remembered better and longer than words (Paivio 1983). Many studies support this notion (Mintzer and Snodgrass 1999), indicating a conceptual advantage for pictures (McBride and Anne Dosher 2002). This was also corroborated in the area of presenting instructions. In a study which examined the comprehension of navigation instructions, it was shown that visual presentation tends to be improved if it includes symbols representing the movements (Healy et al. 2013).

Users often scan instruction manuals with a certain aim, jumping from one part of the text to another. Viewing the text in the manuals with the aim of finding specific information is a visual search task. Search tasks rely on different visual attention processing modes. These modes are considered as bottom-up and top-down processing (Egeth and Yantis 1997). The bottom-up mechanism depends on the properties of the stimulus, while the top-down is determined according to the observer's goals. Both mechanisms work together interactively during visual search in manuals. For example, when a user takes a look at a page of a manual, visually salient elements of the page (e.g. highlighted headlines) catch his eye immediately, which can be explained by bottom-up mechanisms that act early in the visual perception process (Connor, Egeth, and Yantis 2004). After that, the top-down mechanisms, that invoke cognitive interpretation, take over. These mechanisms are guided by the aim of finding specific information (e.g. finding out the drying time for a product) and they include the process of intentionally selecting those visual elements on the page that are relevant for the user's aim (e.g. paying attention to the picture representing the stopwatch and numerals that indicate drying time). The importance of top-down mechanisms was supported by a recent study by Huestegge and Radach (2012) who demonstrated that top-down processing plays a significant role during search processes while scanning displays containing juice packages. Nevertheless, search procedures can also be determined by bottom-up processing aroused by graphic design of the textual and pictorial content.

2. Problem statement

Our study had two purposes: (1) to examine whether the inclusion of pictograms in instruction manuals would enhance the visual search for target textual information; (2) to investigate whether the visual similarity between the pictograms and the adjacent text helps improve the visual search in manuals. As starting points for this effort we used some well-known principles of users' visual perception during information seeking. The following paragraphs give insights into these principles and describe the theoretical background for each of the purposes in this study. The first paragraph talks about the influence of the inclusion of pictograms on cognitive processing, while the second paragraph talks about the perceptual grouping of similar visual elements during the visual search.

2.1. Pictograms

Users' cognitive processing is facilitated when pictorial and textual content work together to communicate the instructional message (Clark and Mayer 2011). The reason for that is that the integration of pictograms and text results in active processing of the information. Users are encouraged to mentally construct pictorial and textual representations of the instructional material and to build connections between them. This process of integration of information from the two different sources is enhanced if the distance between the text and the pictograms is short enough (Holsanova, Holmberg, and Holmqvist 2009), so it is advisable to present the corresponding text and the pictograms contiguously rather than separately (Mayer and Moreno 1998). The closer on the page they are, the closer they feel cognitively (Williams 2003). Based on these findings, we predict that adding relevant pictograms close to the textual content can be helpful in visual search.

2.2. Similarity

In situations where users view the text in the manuals with the aim of finding specific information, they use a search strategy which mostly depends on individual experiences, knowledge or expectations of where that information should be (Yang 2012). Users tend to look at informative regions while looking at the scene (Henderson et al. 2007). To seek effectively in the scene, they should have at least some knowledge in the field of the presented information (Ans and Tricot 2009). Therefore, in the process of searching for the target information, users look up those pieces of information that are similar to the ones that are already known to them.

While viewing a large amount of visually presented information, the perceptual grouping of similar visual elements is particularly useful (Aspillaga 1997). Perceptual grouping is the process by which visual elements are gathered into larger and more meaningful collections (Feldman 1999). These perceptual organisation operations in the human visual system are automatic and they are so flexible that grouping processes are quite efficient even when visual processing is hindered (Montoro, Luna, and Ortells 2014). They enable the user to categorise information in bulk, in a way to facilitate visual search (Anderson 2004).

The basic assumption of our study is that the grouping of similar elements in instruction manuals results with faster detection of the target information. When users buy a new product (e.g. a sewing machine), they often use the manual if they want to get an answer about that product (e.g. how to change a needle). In the process of searching for the answer, they pay attention to those visual elements on the page that are both relevant for the search task and familiar to the users (e.g. pictogram of a needle replacement). They expect the target information to be similar to those elements (e.g. if the pictogram of the needle replacement is bold, it is expected that the textual description of the needle replacement procedure will also be bold). If the similarity exists, we assume that the process of finding the information should be faster compared to the condition in which the relevant and familiar pictograms are not similar to the target information. Thereby, for effective visual search it is essential to provide the coherence of text (Naumann 2009) and to design the pictograms while giving consideration to simplicity, concreteness, meaningfulness and familiarity (Chan and Ng 2010; Chan and Chan 2013) in order to ensure clear mental representations in the users' minds. In doing so, they should be formed to be as comprehensible as possible (Lesch et al. 2013).

2.3. Choice of measuring method

Eye-tracking equipment provides an objective method for measuring human visual search paths. This technology has been widely applied to the studies on visual attention and users' visual behaviour while looking at textual and pictorial elements (Pieters and Wedel 2004; Ryu, Suh, and Dozier 2009). It has been of particular importance for the better understanding of user information processing (see, Feiereisen, Wong and Broderick [2008], for example). Recently, it has also been used to study various ergonomic issues (Underwood et al. 2003; Savelsbergh et al. 2005; Lehtonen et al. 2013), especially in the field of visual search (Araujo, Kowler, and Pavel 2001; Findlay 2004). Whereas there is a growing body of literature regarding the use of eye-tracking measures in studies of visual search in website design (Burke et al. 2005; Lam, Chau, and Wong 2007; Wang et al. 2014), much less attention is paid to eye-tracking in searching instruction manuals (Cowley and Wogalter 2011). In trying to fill this research gap, the present study connected this technology and visual search in instruction manuals that were designed using text and pictograms in different combinations. The eye-tracking measurements were undertaken in order to answer the following questions. First, how does the use of pictograms in instruction manuals improve the visual search for information? Another question was whether there was any difference in the visual search among manuals that included different pictogram-text combinations which varied according to similarity?

3. Methods

3.1. Choice of presentation mode

Although manuals are increasingly taking digital (on-screen) form, paper manuals are still the most popular method of communicating instructions. The main difference between the screen and the paper presentation mode of manuals is that effective gathering information from the screen manuals requires the presence and knowledge of the use of an electronic digital reading device. Another difference is the ease with which users can control their reading activity while using paper manuals. This benefit most particularly refers to the multiple-page structure of the manuals. In order to ensure that screen and paper presentations were designed as similarly as possible (Noyes and Garland 2008), our study included one-page documents in a format suitable for reading from paper. While viewing only one page, participants were able to gain visual control over the entire instructional content in the same manner as if they were viewing print manuals.

Furthermore, in the context of the diversity of the presentation medium and its influence on search behaviour, it should be noted that today the advancements in screen technology enable better computer and paper equivalence. For example, some studies have shown that reading time is unaffected by the presentation mode (Switchenko 1984; Askwall 1985; Muter and Maurutto 1991). As the population becomes more oriented towards new media, new styles of reading and skimming can be expected. Accordingly, users in our study are represented by a younger generation of participants who are familiar with computers and reading from screens.

3.2. Participants

Sixty-four observers participated in this study. All of them were students at the University of Zagreb, Faculty of Graphic Arts, who voluntarily participated in the experiment. Their ages ranged from 20 to 26 years of age (M = 21.56, SD = 1.58). 64% of the participants were female and 36% were male. All of the participants had normal vision or corrected-to-normal vision.

3.3. Designing the stimuli

Sixteen instruction manual pages were used as visual stimuli (four per condition). Issues with the size of the set of experimental stimuli limited our conclusions on complex cognitive processes, but provided useful background information into users' visual search. Stimuli were designed especially for the purpose of the study. By providing advice and instructions for the proper use of a product, each page presented a different theme in one condition: using a sewing machine, working with carpentry, preparing tea and glass painting. The combination of the theme and the type of the stimulus varied across the experiment. Each of the pages consisted of textual and pictorial content.

3.3.1. Designing the textual content

Although there is no common formula for effective typography design (Camnalbur and Mutlu 2011), researchers suggest careful choice of some design parameters. Considering that text layout affects searching performance (Lonsdale, Dyson, and Reynolds 2006), we followed the literature that refers to typography and layout recommendations.

Mostly, it is recommended to use sans serif fonts for screen presentation (Powell 2002; Arditi and Cho 2007; Akhmadeeva, Tukhvatullin, and Veytsman 2012), especially for instructional manuals (Schriver 1997). Accordingly, the sans serif Myriad Pro typeface was used throughout the text in our stimuli. When it comes to defining the type sizes, 12 and 14 pt enable comfortable reading, but 10 pt also provides satisfying legibility (Havig and Ng 2007). Ten pt was more appropriate in our study since smaller sizes of typefaces are more typical for the genre of instructional manuals. The main reason for that is the reduction of the area covered by the text and, accordingly, the decrease in production cost of the manuals (Legge and Bigelow 2011). Given that the line spacing of one to one-and-one-half times the type size is suggested by most authors (Galitz 2002; Camnalbur and Mutlu 2011), 12 pt was used for spacing between the lines in our stimuli.

According to Dyson (2004), in investigating reading and associated performances, the variable relating to the line length measured in characters per line should be constant. While Schriver (1997) suggests 60–70 characters per line, Marcus (1995) recommends 40–60 for comfortable reading. We decided to define this variable according to the results of Dyson and Haselgrove (2001), since they ground their findings on readers' comprehension which is an important factor in our study. They have found that 55 characters per line produce better comprehension scores. In our study, the number of characters per line ranged from 47 to 66, M = 55.25, SD = 3.59 (excluding last lines of paragraphs). The number of characters (with spaces)

Table 1. Specifications of stimuli.

Stimulus	Stroke thickness of the pictograms	Character style of the adjacent text	Pictogram-text similarity
Thin-Regular	0.7 pt	Regular	Similar
Thin-Bold	0.7 pt	Bold	Dissimilar
Thick-Regular	1.6 pt	Regular	Dissimilar
Thick-Bold	1.6 pt	Bold	Similar

ranged from 4479 to 4519, the number of words ranged from 655 to 694, while the number of lines remained the same (81) for all of the pages. Hyphenation was prevented, since excessive hyphenation disrupts reading (Carter, Day, and Meggs 1993).

Our stimuli were designed as a double-column layout. Not only was it found to be scored better subjectively (Dyson and Kipping 1997), the double-column layout provides better readability compared to a single-column layout (Hartley, Burnhill, and Davis 1978). Separation of paragraphs is also one of the typographic features that have a positive influence on the readers' performance (Hartley, Burnhill, and Davis 1978; Lonsdale, Dyson, and Reynolds 2006), so we used 5-mm indents at the beginning of each paragraph.

3.3.2. Designing the pictorial content

The pictograms included in the stimuli were designed according to Chan and Chan (2013), and Chan and Ng (2010), so they were simple, concrete and familiar to participants. The guiding idea in designing them was to develop highly understandable pictograms (Wogalter, Sojourner, and Brelsford 1997). To minimise the potential ambiguity, the design of the pictograms included typical elements from the represented objects (Bruyas, Le Breton, and Pauzié 1998). For example, in the depiction of a glass we used the form with a stem and a foot, rather than a regular water glass without any recognisable details. Furthermore, the pictograms were framed with the shape of a square, since this shape is the most common for conveying information with general intention (Liu et al. 2010). In order to enhance the text-picture integration, they were formed as blocks of information in a serial format (Holsanova, Holmberg, and Holmqvist 2009). The size of each pictogram was 4 × 4 cm.

3.3.3. Designing the independent variables

The pages were designed to vary in terms of similarity between the pictograms and the adjacent text. This similarity was generated by manipulating the stroke of the pictograms and the character style of the letters (since character style defines stroke of the letters). These variables were chosen as determinants of similarity because they are basic structural elements of visual form, both for pictograms and letters. Another reason is a practical one: they can be easily controlled by the graphic designer in the process of making the instructional manuals. The specifications of the stimuli are presented in Table 1 and depicted in Figure 2. The values for stroke thickness of the pictograms were defined according to the stroke of the letters in the adjacent text (the width of the steam of the letters). The value of 0.7 pt for thin stroke was converted from letter stroke in regular style (the width of the steam 0.25 mm), and the value of 1.6 pt for thick stroke was converted from letter stroke in bold style (the width of the steam 0.56 mm).

Each page consisted of the following sections: the pictograms, the adjacent text and the body text. One such example is shown in Figure 3. The disposition of these sections, as well as the typographic design of the body text, was unchanged in all of the pages.

3.4. Apparatus

The stimuli were presented on a Lenovo computer display (model LEN L1900pA) and viewed from a distance of 60 (±1) cm. The resolution of the computer screen was set to 1280 × 1024 pixels with a refresh rate of 60 Hz. The measurement methods used were: the percentage of the participants who clicked on one of the two possible areas with the target information, the response time and the number of fixations required for finding the target information. The participants' response times were recorded using a standard PC mouse. The number of fixations was recorded with Tobii Eye Tracker X60 with a sampling rate of 60 Hz and an accuracy of 0.5°. The presentation of the eye-tracking stimuli was created using the Tobii Studio 3.2.1. software.

3.5. Procedure

The participants were seated in front of a monitor in a quiet and slightly dimmed room. Each participant took part in an individual session which started with a 5-point calibration of the eye tracker. At the beginning of the session, the participants were given a short explanation of the procedure using an example of an instructional manual page which was not included in the analysis. The participants were asked to focus on the accuracy of their performance. After listening to the explanation, the experiment started. Each trial of the session began with the presentation of the question in the middle of the screen. When the participants confirmed that the presented question was clear and

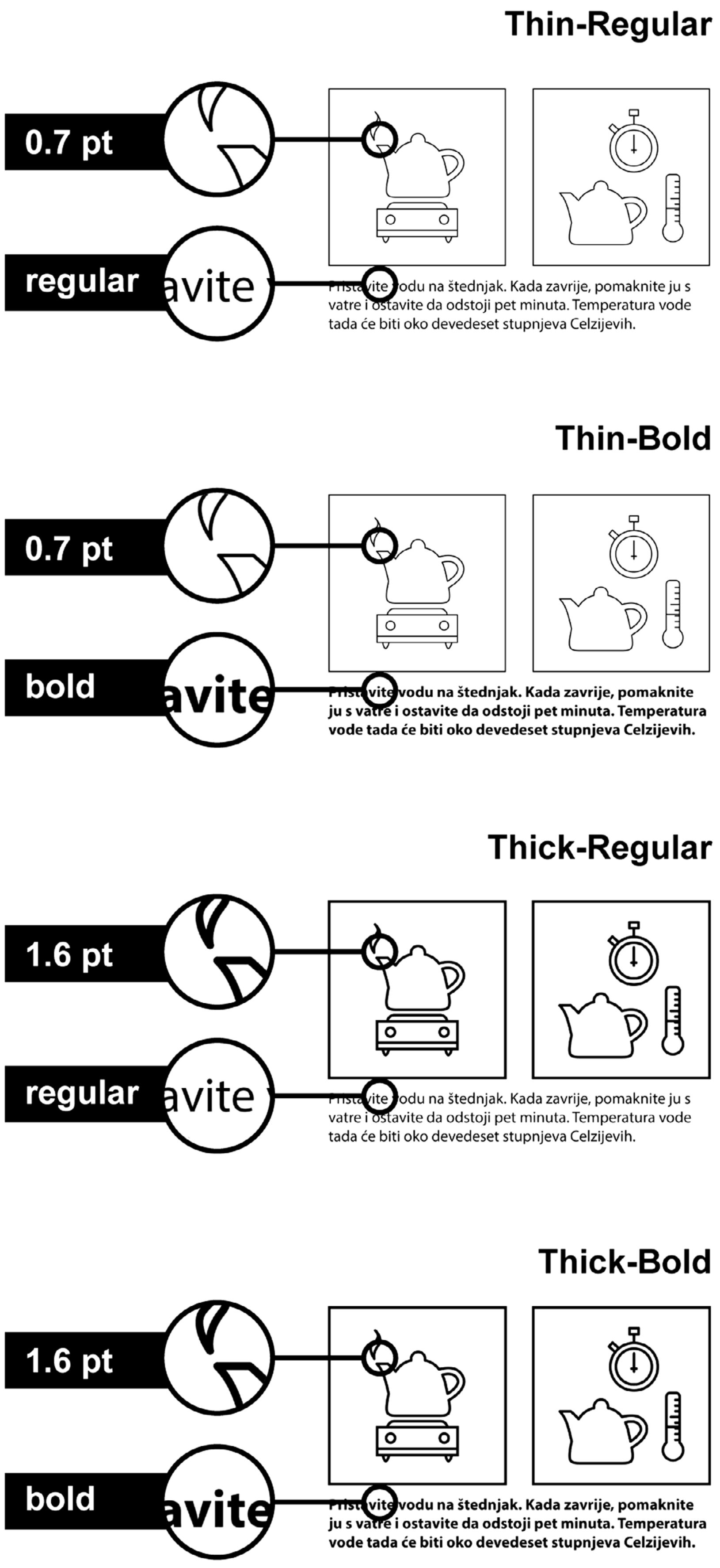

Figure 2. Depiction of stimuli specifications.

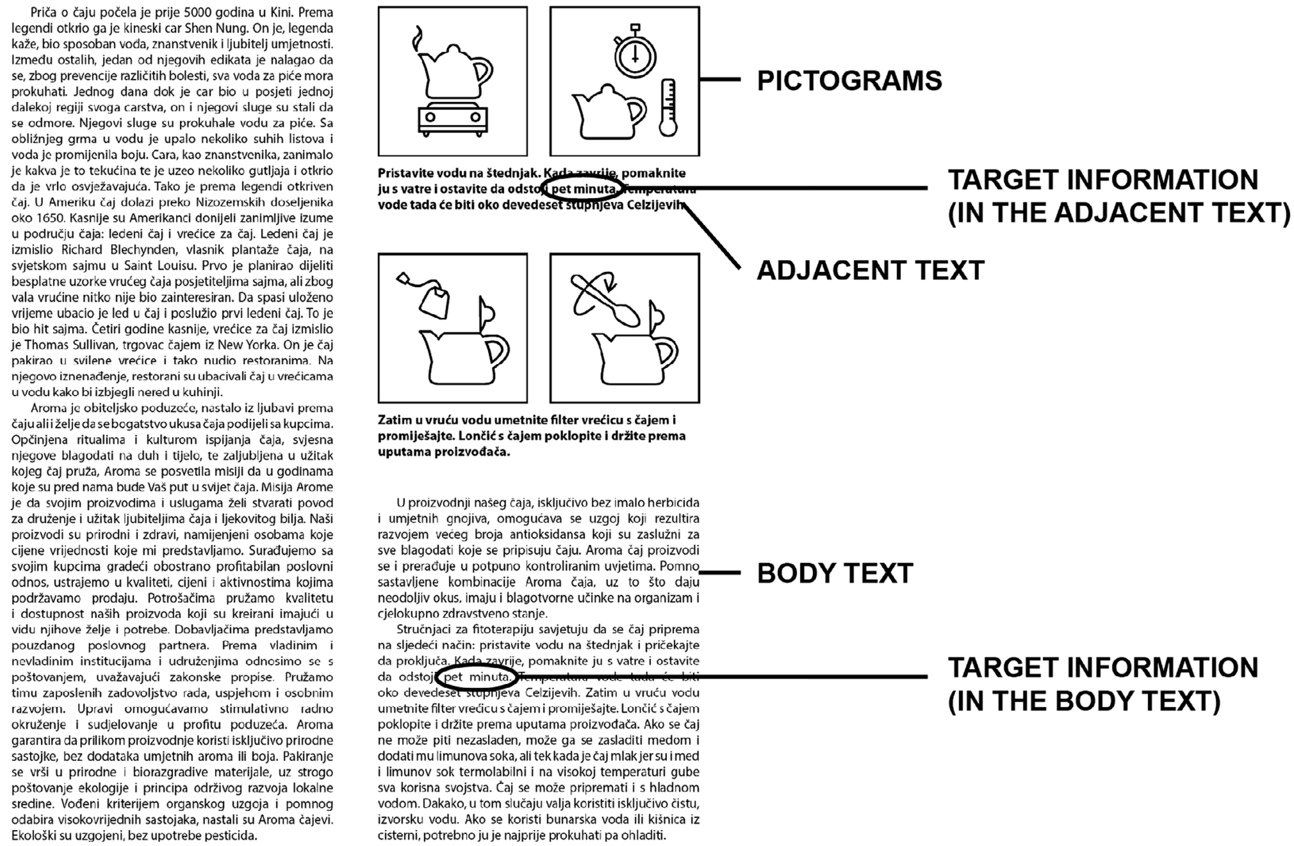

Figure 3. An example of one of the stimuli (Thick-Bold).

they felt ready to continue, one of the manual pages was displayed. Participants were instructed to find the answer on the page and to click on the area within the page where the answer was found. This was of particular importance because the pages were designed to contain the same answer twice – once in the proximity of the pictograms (in the adjacent text) and once in the body text (in the last paragraph at the bottom of the page). The participants were not informed about that. The following questions, each associated with one theme of the manual page, were included in the experiment: (1) 'How many times should you turn the handwheel of the sewing machine?' (2) 'What size of sandpaper is advisable for sanding a window?' (3) 'How long does it take to cool boiling water for tea?' (4) 'How long does it take for the contour color on the glass to dry?'. The questions were formed in such a way so that the answers were numerical values. In order to reduce the possibility of quickly recognising the numerals in a batch of text, all numerical values were in textual form (e.g. 'three' times, 'ten' minutes). One of the pictograms indicated the correct answer that was placed in the associated textual information. For example, in the case of the cooling of the boiling water for the tea, the pictogram was a depiction of a timer, but it did not show the information about the exact time. Participants were given unlimited time to find the answer. They were also informed that there was no need of reading the whole text, and instructed to use their own information search strategy. After the participants signalled by mouse click that the answer was found, an empty screen was presented for 2 s. Then, the next question was shown and the same procedure was repeated. For each session, the order of appearance of the pages was randomised. During the experiment, the response time and the number of fixations for each participant were measured. The response time was calculated from the moment the manual page was presented on the screen until the participants clicked on the correct answer. The number of fixations was calculated by counting the fixations with a minimal duration of 60 ms (radius 50 px) during the response time. The area where the participant clicked for the answer was also recorded.

4. Results

The results are presented according to the research questions. The first section refers to the influence of pictograms on visual search. This section provides the percentage of the participants who found the information in different areas as a measure of the participants' preferences in visual search, and response time as a measure of visual

Table 2. Percentage of participants who found the information in one of two possible areas.

Stimulus	The adjacent text (%)	The body text (%)
Thin-Regular	55	45
Thin-Bold	70	30
Thick-Regular	65	35
Thick-Bold	83	17
Total	68	32

Table 3. McNemar's test.

	Thick-Regular/ Thin-Regular	Thick-Bold/ Thin-Regular	Thin-Bold/ Thin-Regular	Thick-Bold/ Thick-Regular	Thin-Bold/ Thick-Regular	Thin-Bold/Thick-Bold
Exact Sig. (2-tailed)	.016	.000	.002	.007	.581	.057

search time. It also presents the visualisations of fixations and eye-movement patterns as measures of participants' attention.

The second section refers to the influence of the similarity of the pictogram-text combinations on visual search. In this section the response time and the number of fixations were taken as a measure of visual search.

The data were not normally distributed so nonparametric tests were used.

4.1. Pictograms and visual search

4.1.1. Search preferences

Search preferences were determined by the area in which the target information could be found. There were two possible areas where participants could find the information: (1) in the adjacent text and (2) in the body text. For the participants who found the information in the adjacent text, we defined their search preferences as 'prefer to look for the answer in the proximity of pictograms'. For the participants who found the information in the body text, we defined their search preferences as 'prefer to look for the answer in the area further away from the pictograms'.

Table 2 shows the percentage of the participants who found the information in different areas of the instruction manual pages. The highest such percentage was in the case of the pictogram-text similarity when the participants found the information in the adjacent text.

The Cochran's Q test showed significant differences in search preferences for different stimuli (Cochran's $Q = 25.99$, $p < 0.01$). This test was followed by McNemar's *post hoc* test with Bonferroni's correction, so only the p-values below 0.01 were considered significant. The results are shown in Table 3. While viewing those stimuli that had the same stroke thickness of the adjacent text, the participants did not differ significantly in their choice of where to look for the answer, in the proximity of the pictograms or in the area further away from them. On the other hand, while viewing those stimuli that differed according to the stroke thickness of the adjacent text, search preferences differed significantly. These results indicate that significantly more participants preferred to look for the information in the proximity of the pictograms if the adjacent text was bold, rather than regular.

4.1.2. Visual search time

The Mann–Whitney test showed a statistically significant difference between the response times in different instruction manual pages, $U = 4503.50$, $p < 0.01$, $r = -0.52$. The participants who searched for the information in the adjacent text (Mdn = 16.56, range 6.57–121.79) needed less time than those participants who searched for the information in the body text (Mdn = 39.82, range 8.05–141.79).

In order to examine the influence of the boldness of the adjacent text, we conducted the Mann–Whitney test to compare the stimuli with the different character styles of the adjacent text. The test showed no statistical difference in visual search time between the stimuli with the bold style (Mdn = 15.16, range 6.57–103.70) and the regular style (Mdn = 15.16, range 6.82–141.79) of the adjacent text, $U = 492.50$, $p > 0.05$.

4.1.3. Attention

The number of fixations and its visualisations were presumed to reflect the participants' visual attention. Figure 4 shows the visualisations of the scan paths of two typical participants. Lines represent saccades, circles represent fixations and numbers inside the circles indicate the ordinal number of the fixation. The participants who searched for the information in the adjacent text (Mdn = 49, range 19–299) needed less fixations than those participants who searched for the information in the body text (Mdn = 127, range 25–453).

4.1.4. Eye-tracking scan paths

Table 4 shows the eye-movement patterns (Figure 5) of those participants who found the information in the adjacent text. Most of them started their search by fixating on the pictograms. One quarter of the participants also fixated on the pictograms before finding the target

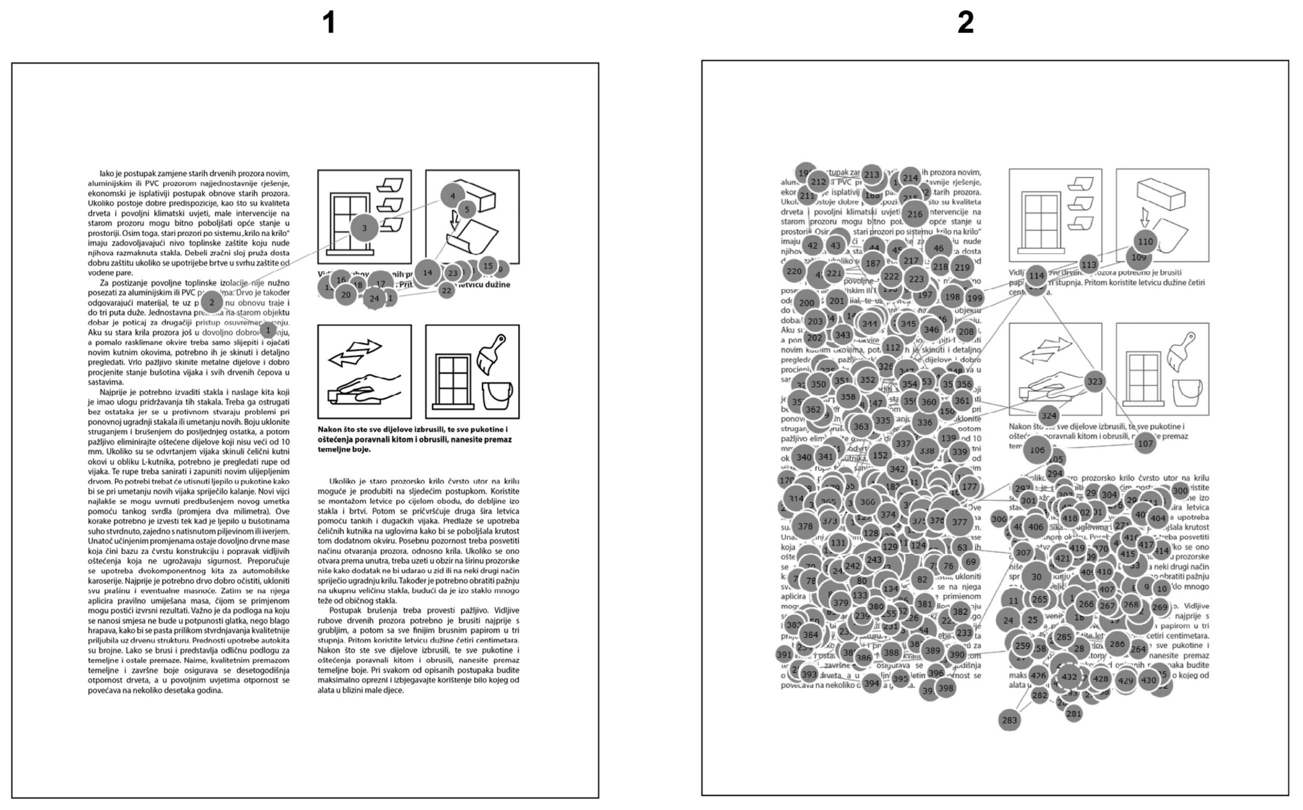

Figure 4. Examples of scan paths of two participants; 1 – the one who prefers to look for the answer in the proximity of pictograms, 2 – the one who prefers to look for the answer in the area further away from the pictograms.

Table 4. Eye-movement patterns of those participants who found the information in the adjacent text.

Scan path	Percentage (*N* = 44) (%)
Left part of the page – Pictograms – Adjacent text – Target information	25
Left part of the page – Adjacent text – Target information	7
Pictograms – Adjacent text – Target information	57
Adjacent text – Target information	11

information, but they started their search using the usual reading path (e.g. parts of the pages are viewed from left to right and pages are read from top to bottom), so we cannot claim that they found the target by virtue of the pictograms. The smallest percentage of the participants (18%) found the information in the adjacent text without fixating on the pictograms.

4.2. Similarity of pictogram-text combinations

The data measured from the participants who found the information in the adjacent text were used for the analysis of the influence of the pictogram-text similarity on the information visual search time. The median of the response time and the number of fixations were taken as a dependent parameter (Table 5).

The Friedman test showed significant differences in response times for different instruction manual pages ($\chi^2(3) = 13.73$, $p < 0.01$). Comparisons between each manual page were then performed using a *post hoc* Wilcoxon test (Table 6), with Bonferroni's correction applied. The only statistically significant difference that was found was the one between the Thick-Bold and the Thick-Regular stimuli, $Z = -3.88$, $p < 0.01$, $r = -0.66$, indicating that the participants needed less time to find the information on the manual page with the pictogram-text similarity with the bold typeface (Mdn = 20.39, range 10.11–67.50), compared to the page with the pictogram-text dissimilarity with the regular typeface (Mdn = 59.00, range 10.42–121.79).

5. Discussion

The main goal of this study was to investigate the influence that the use of pictograms and the similarity between the group of pictograms and the text have on visual search in instruction manuals. In general, our data suggest that pictograms in some extent do improve visual search. On

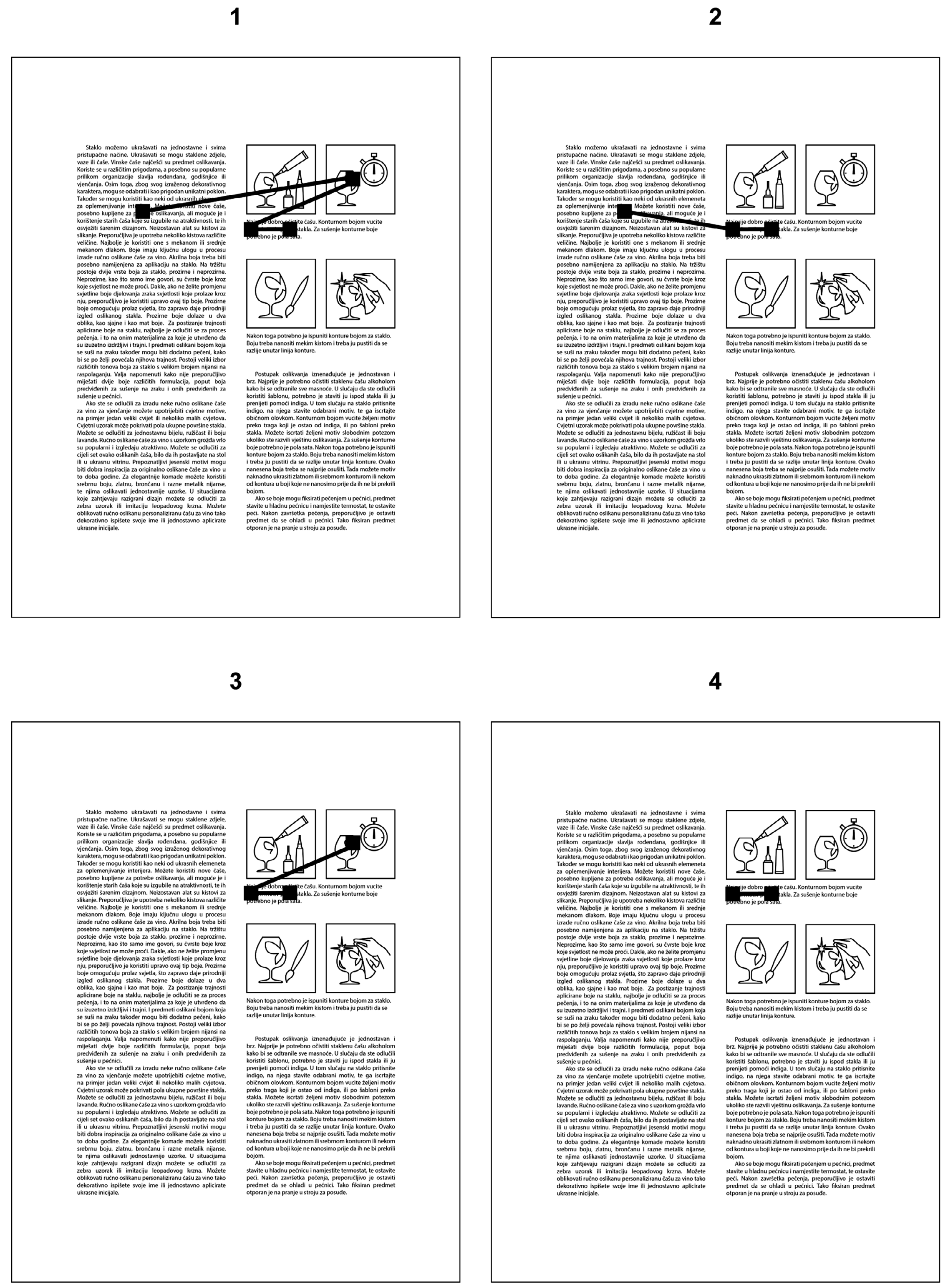

Figure 5. Visualisation of the eye-movement patterns of those participants who found the information in the adjacent text; 1– Left part of the page – Pictograms – Adjacent text – Target information, 2 – Left part of the page – Adjacent text – Target information, 3 – Pictograms – Adjacent text – Target information, 4 – Adjacent text – Target information.

Table 5. Response time and number of fixations for each stimulus.

Stimulus	Response time median (range)	Number of fixations median (range)
Thin-Regular	16.11 s (7.31–96.99)	48 (21–290)
Thin-Bold	10.60 s (8.05–100.87)	31 (24–298)
Thick-Regular	59.00 s (10.42–121.79)	177 (31–299)
Thick-Bold	20.39 s (10.11–67.50)	61 (30–202)

Table 6. Wilcoxon Signed Ranks Test.

	Thick-Regular/ Thin-Regular	Thick-Bold/ Thin-Regular	Thin-Bold/ Thin-Regular	Thick-Bold/ Thick-Regular	Thin-Bold/ Thick-Regular	Thin-Bold/Thick-Bold
Z	−1.704	−.934	−.983	−3.882	−2.261	−.131
Exact Sig. (2-tailed)	.088	.350	.326	.000	.024	.896

the other hand, pictogram-text similarity does not affect visual search performance.

Three measures were used in answering our first research question about the use of pictograms and its influence on visual search: search preferences of the participants, visual search time and visual attention. In investigating the participants' search preferences, we discovered that most of the participants preferred to look for the information in the adjacent text (proximity to the pictograms), rather than in the body text (the area further away from the pictograms). This result is in line with the spatial contiguity principle recommended by Clark and Mayer (2011), which refers to placing the text near the corresponding graphics. When users perceive graphics and accompanying texts that are integrated, they are able to hold them together in working memory. This results in building connections between corresponding pictorial and textual information. Another explanation for the participants' tendency for searching the target information near the pictograms is the attention-grabbing power of pictorial presentations, since they attract attention more quickly than text. This notion was corroborated in Pieters' and Wedel's (2004) study of attention to advertisements, where it was shown that pictorial content draws great amount of baseline visual attention during users' exploration of an ad. Another study of Lohse and Wu (2001) showed that graphics attract more attention than text-only ads. In their experiment, participants spent twice as much time viewing ads with graphics.

However, some studies do not support this result. For example, Feiereisen, Wong, and Broderick (2008) showed that the use of words is more suitable in enhancing product comprehension than the use of pictorials. In some previous examinations of search effects on display ads, Lohse (1997) has found that ads with graphics did not capture the viewer's initial attention and did not affect the viewing order. While noticing discrepancy between the results of our study with those in the previously mentioned researches, the characteristics of the search task should be taken into account. In our study, the target information was constructed in the form of an answer. Answering a question requires the participants to imagine a representation of what information is needed and why (Rouet and Coutelet 2008). In the study of Rayner et al. (2001), it was found that the goals of the users affect the manner in which they look at the stimulus. As argued in their study, users have a tendency to look at that part of the stimuli that is maximally informative to their goals. In line with that tendency, they scan the pictorial or textual content depending on what is most functional for their goals.

Another finding of our study was that the participants who found the information near the pictograms had a better visual search performance, i.e. they needed less time to complete the task. These results are in accordance with the study of Rouet and Coutelet (2008), where faster search speed was recorded by those participants who looked for pictures, headings and keywords in order to find relevant parts of the text while searching for an answer in encyclopaedia pages. This could additionally be explained by the familiarity of the presented pictorial information, as familiarity speeds visual search (Wang, Cavanagh, and Green 1994). The participants noticed the pictograms that had strong and familiar association with the information which they were looking for, and perhaps they intuitively searched for the target information in that neighbourhood, which shortened their search time. On the other hand, the participants who did not pay enough attention to the pictograms did not have an eye-catching element which could indicate the target information to them. Subsequent detailed analyses of the eye-tracking data showed that these participants spent a lot of time on carefully reading the large amount of text (Figure 4), or on jumping from one part of the page to another without a clear search strategy. Although pictograms do affect the visual search for target information in continuous text, we cannot predict that the use of pictograms would enhance the comprehension of the presented information. For example, Liu, Kemper, and McDowd (2009) showed that older users may not benefit from illustrations in combination with text, because of the difficulties with integrating the illustrations with the textual information.

In contrast to our expectations, this study showed that the pictogram-text similarity does not affect visual search performance. As revealed by Cochran's *Q* test, it also does not influence the search preferences. Although applying the similarity as one of the Gestalt laws is suggested by literature in order to make effective textual and graphic designs (Moore and Fitz 1993), our data showed that that was not the case in this study. This may have happened because we had not examined other determinants of similarity in enough depth. We manipulated the similarity only by stroke thickness, while other possible variables were excluded (e.g. colour). In comparison with the similarity effect, it seems that highlighting had some influence on the facilitation of the search process. Although there was no statistically significant difference in the visual search between the regular and the bold adjacent text, our results showed that the shortest visual search time was in the case of stimulus in which the adjacent text was designed as the only highlighted content. In the study of Ponce and Mayer (2014), where the number of fixations was used to examine the effects of highlighted elements on reading patterns, it was shown that highlighting prepared the participants for the cognitive process of selecting. In our study, highlighting was realised using bold typeface. Bold typeface is suggested as one of the techniques for highlighting the target information (e.g. [Muter 1996]) in order to achieve optimisation of reading a continuous text. Many studies have shown a positive impact of bold style on attracting visual attention. In the study of eye movements on yellow pages advertising (Lohse 1997) it was concluded that bold listings capture attention by making ads easier to read. In the study which examined the effects of highlighting on visual search performance (Wang, Wang, and Ting 2012) it was shown that bold highlighting enabled faster visual searches.

Further explanation of the superiority of highlighting over similarity can be based on the pop-out effect. Visual information pops out if it has a unique perceptual feature (Treisman 1998) which makes it different from its surrounding. The distinction of that information is amplified if the surrounding is extremely homogenous (Ware 2008). However, we cannot say that information with pop-out properties always reflects on the visual search time. To have an effect on the visual search for some target information, the difference between the target and the surrounding should be big enough (Treisman and Gelade 1980). In our study, the bold letters were in minority and they were surrounded with a lighter version of typeface, which is a setting for effective differentiation. It should be taken into account that other settings could result in different findings driven by search asymmetry. Search asymmetry relates to situations when one type of element pops out among other types, but not in the reversed search (Treisman and Souther 1985). For example, regular letters will not stand out in a field of bold letters as much as bold letters will stand out in the field of regular letters.

In the study of visual search processes that explain how people search for objects on maps (Lloyd 1997), it was discovered that target symbols that pop out of the map improve the efficiency of the search. This could be the reason for the shortest visual search with Thin-Bold pictogram-text combination in our study. The target information was located in the bold adjacent text which was the most highlighted block of information on the whole page.

Our data showed that the highest number of fixations was for the Thick-Regular stimulus. A greater number of fixations indicate that the participants looked at many other elements before finding the target information. Some parallels can be drawn with Goldberg and Kotval's (1999) study. In their experiment, the eye movement measurements were recorded while presenting users with different interfaces that varied in the visual organisation of the elements. Their data showed that a well-organised interface with visually grouped components resulted in shorter scan paths compared to a randomly organized interface. The Thick-Regular combination of the pictograms and the adjacent text in our study was perceived as a poorly organised stimulus that led to a less directed search with more fixations. A stimulus that is difficult to encode requires a greater number of fixations (Hyönä 2010), and more fixations indicate a less efficient search (Poole and Ball 2006) driven by the layout of the page.

At the end of this section, it would be interesting to look back on the results of the participants' search preferences. According to our results, the highest percentage of the participants who found the information in the proximity of the pictograms was in the case of the Thick-Bold stimulus. This stimulus presented the pictograms and the adjacent text as a highlighted group of information. It appears that designing the pictograms and the adjacent text in a visually grouped block of information had a positive influence on the participants' tendency to use the pictograms as help for finding the target information. This is mainly because people expect grouped elements to be related by some common characteristic (Goldberg and Kotval 1999). When the participants noticed the pictogram that represented the concept which was recognised as a cue for finding the answer they were searching for, they probably expected that the adjacent text contained information related to the pictograms.

To sum up, the findings of our study show that the inclusion of pictograms speeds up the information search in manuals. Unlike the similarity effect, the visual prominence of the most informative content could also ease the information seeking.

6. Conclusions

When it comes to facilitating users' search for information in instruction manuals, highlighting of relevant information has been demonstrated to be a more important factor than visual similarity between related pieces of information. Furthermore, based on our results, it is advisable for designers to include pictograms as guides for directing the users' attention to key elements of the manuals. This could also be a useful guideline in designing other visual presentations where it is important to quickly notice particular information.

However, it is plausible that a few limitations to the study might have influenced the obtained results. Firstly, the current study was limited by the screen presentation mode. Despite this, we believe our work could be a framework for enhancing the flow of information in instruction manuals, especially those in the form of one page. Furthermore, our method of visual search investigation differed from the procedure used in most other studies, which is based on the participants' report about the presence or absence of a target in a display of distractors. In our study, the target information was present in every stimulus. The main reason for this modification in methodology was an attempt to achieve experimental conditions as close to the participants' daily life as possible. In reality, the instruction manuals contain all information that is relevant to a user before the first handling of a product, so there is no possibility of absence of the information searched for. Another limitation was the young age of the participants. Although the selection of participants was in line with the screen presentation mode, we cannot expect our results to be applicable for older users who might interpret pictograms in a different manner and spend more time on visual search. Furthermore, our findings might not be generalised to some other types of manuals with a different layout and structure of the text.

Further studies should also look into the other types of instructional manuals in order to get a clearer image about visual search patterns. Effective search for information has an essential role in using these documents, since the efficacy of finding the relevant information affects users' satisfaction with a product, and, even more important, it affects their safety while handling the product.

Disclosure statement

No potential conflict of interest was reported by the authors.

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