MODE OF TEXT PRESENTATION AND ITS INFLUENCE ON READING EFFICIENCY: SCROLLING VERSUS PAGINATION

Zuzanna KŁYSZEJKO, Anna Maria WIECZOREK, Justyna SARZYŃSKA, Agnieszka SZÓSTEK, Karolina CHMIEL, Tomasz SOLUCH, Aneta BRZEZICKA

Warsaw University of Social Sciences and Humanities
Chodakowska Street 19/31, 03-815 Warsaw, Poland
E-mail: anna.maria.wieczorek@gmail.com

Abstract: In the last decades, the Internet has developed into a proliferating and flourishing source of information. This phenomenon requires complex pieces of writing to be presented in a way that expedites their efficient processing. This paper presents an experiment studying how text presentation affects reading efficiency and text recall. We compared different types of text presentations - scrolling and text pagination with and without callouts. A word recognition task was used to assess the recognition of a presented text. Discrepancies in reading efficiency were apparent in the results obtained from the eye tracking data; namely, we noted that scrolling is more demanding than reading paginated text in terms of the processing time. Our findings provide support for claims of more efficient processing of paginated texts. Such text presentation appears to have a strong influence on cognition that should be taken into account by designers whenever visualizing complex texts online.

Key words: text processing, HCI, scrolling, pagination, levels of processing, eye movements

INTRODUCTION

In the last decades, the growth of digital and the decline of analog media have required new ways of text presentation. Landow (1992, 1997) and Bolter (1991, 2001) noted that in digital reading the boundaries between chunks of text were no longer clear, the way they used to be in the analog world. Liu (2005) and later Mangen (2008) concluded that on-screen reading is characterized by more time spent on browsing and scanning, keyword spotting, one-time reading, non-linear reading and selective reading, while less time is spent on in-depth and concentrated reading. Such behavior is stimulated by exposing online users to vari-

Acknowledgements: This experiment was conducted in cooperation with Neuro Device Group (Warsaw, Poland), which provided eye-tracking equipment and software necessary for data analysis. We would like to thank Warsaw School of Social Sciences and Humanities (Warsaw, Poland) for supporting this experiment during the Brain Weekend event. We would also like to thank all participants for their contribution. Finally, we would like to acknowledge the contribution of the members of the Interactive Technologies Laboratory at the Institute for Information Processing (Warsaw, Poland) who offered their views in the planning phase of this study and Paulina Jezierska who helped us with data collection and logistics.

DOI: 10.21909/sp.2014.04.668

ety of elements attracting attention such as links, pictures and videos. Continuous reading requires effortful sustained attention, but readers are inclined to shift their gaze to the distracters. In this context, there is an ongoing discussion regarding the best practices of text visualization in digital media, especially in case of longer and more complex texts that go beyond simple ecommerce-related information (e.g., Morkes et al., 1997; Spool et al., 1997). For example, Spence (2007) distinguishes four ways of representing onscreen information:

- scrolling, showing only the part of information which is currently in focus, while hiding most of the content from view;
- pagination, showing two separate views: one representing detailed content of the area in focus and the other - the overall context of that representation;
- distortion, providing content-related details in the central area of the screen, while on the sides of that area displaying a distorted view of the neighboring information, which can be smoothly moved between the context and focus, therefore encoding the continuity of different elements;
- suppression, based on the concept of 'degree of interest', which defines what kind of information should be presented depending on its relevance to the information presently in focus.

All these visualization techniques are widely used on the Internet, not all of them, however, are equally useful for representing complex texts for a wide audience. In this context, this article investigates which visualization techniques could facilitate more effective information processing for such complex texts online.

We chose to investigate scrolling and pagination techniques for a number of reasons. Traditionally, complex texts (such as regulations, research results, medical recommendations, instructions and many others) tend to be presented online in a PDF format, which enforces scrolling. Thus, we selected scrolling as a baseline condition for this research. At the same time, we are aware of the shortcomings of this visualization method, particularly related to the fact that the reader easily loses the overview of the reading material, which might lead to lower efficiency in scanning the text and higher processing overload. Therefore, as an alternative solution, we chose pagination. Pagination has a number of advantages: it separates the text into comprehensible pieces and, at the same time, provides an overview of the interconnections between these pieces. In the experiment, we aimed to test whether pagination helps people to read complex texts faster and also to process them more efficiently. Additionally, we investigated the influence of callouts placed in the margins. Callouts usually consist of short conclusions or quotes from the main text and we were curious to which extent they support a better comprehension of the presented text.

BACKGROUND LITERATURE

In 1972 Craik and Lockhart suggested that processes such as reasoning and deduction determine reading in a number of ways, depending on the current goals of the reader. Neuroimaging data allows assigning different stages of that process to distinct brain areas (e.g., for visual pathway see DiCarlo et al., 2012).

The sensory aspects of a given stimuli are analyzed on the first, shallow level, and are easy to forget. For example, on this level readers spot words that appear to be similar to words presented in the earlier piece of the text. On the next level the semantic interpretation occurs, which results in processing that is more persistent and less vulnerable to distractions. Processing on the deepest level involves activation of associations with the information processed on the previous levels. The actual depth of text processing depends on factors such as current goals, available time and individual preferences. The work of Craik and Lockhart was further developed by Zwaan and Radvansky (1998), who divided the reading process into three situational models: current, integrated and complete. The current model is constructed iteratively in the process of reading, when each new sentence becomes a basis for a new current model. Then the information from all current models is transformed into an integrated model that enables the reader to choose freely what s/he finds crucial for understanding the whole text. The complete model is finished after the acquired information has been retrieved and updated. Constructing the complete model means that all processed information has been successfully transferred into long-term memory and can be retrieved over time. Studies that stem from this line of research investigate, for example, the influence of semantic content and word prediction on eye movements (for review see: Rayner, 1998).

An alternative perspective regards text as a part of a complex visual environment. Experiments in this line of research are usually conducted as situated studies with participants being asked to read a newspaper (Holmqvist, Wartenberg, 1995; Holmqvist et al., 2003) or to perform a task on a website while their eye movements are recorded for analysis of their reading behavior (Jacob, Karn, 2003; Bojko, 2006; Pannasch et al., 2008). In these studies, which were summarized in Poole and Ball (2005) and Zambarbieri et al. (2008), the results were interpreted in the context of interactions between particular visual elements, such as headlines, information graphics, photographs or quotes and their relative attractiveness in the context of visual attention (Shrestha, Owens, 2009). Using eye-tracking proved to be valuable for investigating ongoing cognitive processes during reading (Rayner, 1998) and visual perception in complex environments (Rayner, 2009). Holmqvist and Wartenberg (1995) investigated the influence of local design factors such as size, information graphics, color, fact boxes and drop-in quotes on eye movements in reading. They asked participants to read a newspaper while their eye movements were measured with a head-mounted eye tracker. Results showed that while most design elements influenced text perception, this effect was different for attracting and sustaining attention. Interestingly, drop-in quotes (in this article termed callouts) positioned inside the text and fact boxes on the margins seemed to be facilitating both types of processing.

In this context, Felici (2003) and Bringhurst (2003) emphasized the role of global design factors in reading of digitalized text. For example, they recommend sans-serif typeface that is appropriate for screen displaying, characterized by suitable x-height and intra-glyph space. Literature from psychology and human factors in turn investigated the influence of text length on information processing. Schwarz et al. (1983) reported that pagination has a positive effect on information processing, and is also superior to presenting the whole text at once, when it comes to user preferences.

More recent studies yield interesting, yet confusing results. For instance, Sanchez and Wiley (2009) observed no significant differences in reading time between groups that read the same text presented on one screen versus several separate screens, as long as individual differences were not taken into account. On the other hand, Baker (2003) suggested that dividing text into separate screens extended the mean reading time. However, none of the recent studies used eye movement data as a dependent variable, combining it with the analysis of the text processing data.

In the view of these results, the present study aims to investigate the interactions between scrolling and pagination with and without callouts, to provide a unique insight into the cognitive processes preceding a recall of complex texts. If dividing text into separate screen increases comprehension (Schwartz et al., 1983), we should observe either decrease or no differences in mean reading time for participants who read the text in its paginated version. In addition, their performance should be better or no different from other participants. We also used callouts that contained quotes from the main text and were placed in the margins. There are two possible outcomes. Either they will increase the performance by facilitating deep processing, or they will act as distractors. High number of transitions between the main text and callouts would indicate inefficiency of the text arrangement, if we also observed a decrease in performance for participants who were exposed to them. If we note higher performance with callouts, it will mean that readers benefit from their presence. To investigate the gaze patterns, as an indicator of underlying cognitive processing, we used eye-tracking.

METHOD

The experiment was carried out in Warsaw, Poland, as a part of the Brain Weekend organized by Warsaw School of Social Sciences and Humanities.

Participants

A total of 42 participants (20 female; mean age M = 34 years, SD = 14.12) with normal or corrected-to-normal vision volunteered to participate in the study. The majority of participants had an academic degree (N = 27; 64.3%), 11 of them (26.2%) graduated from high school and two from primary school. Two participants did not disclose their educational status. None of the participants were familiar with the text used in the experiment or were educated in the topic under investigation.

Materials

We extracted a fragment consisting of 400 words from the autobiography of Maria Skłodowska-Curie (2009) that pertained to the discovery of radium and its most popular applications. It was described by participants as moderately challenging due to a large number of scientific terms. We presented it in four different conditions with 2 (pagination vs. scrolling) x 2 (with callouts vs. without callouts) design. In the pagination mode, we asked participants to navigate between screens using arrows, whereas in the scrolling mode they were allowed to use a mouse to scroll up and down. In the condition with callouts, the exact lines from the text were placed in the margins next to corresponding paragraphs (see Figure 1).

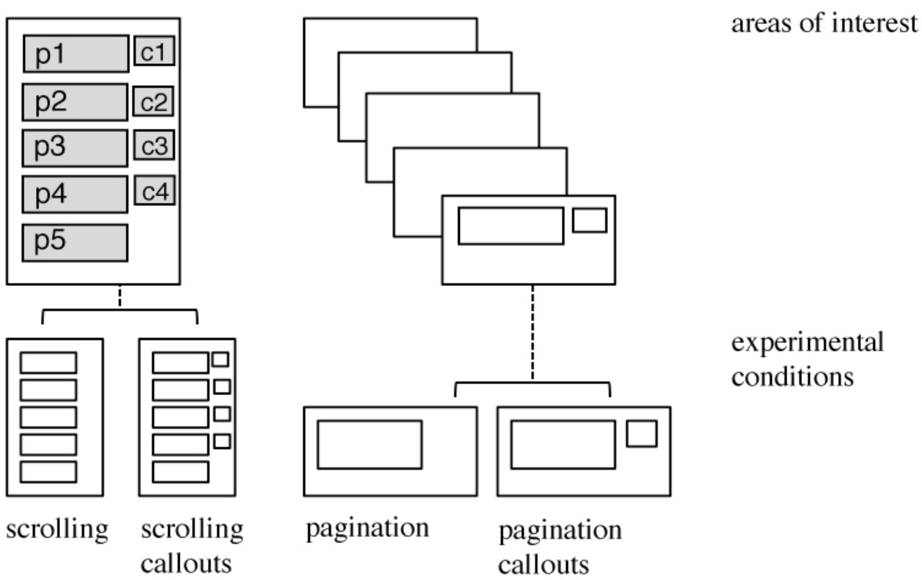

Figure 1. Stimuli used in four experimental conditions. The difference between the condition with and without callouts was limited to quotes from the main body in the right margin. The areas of interest were drawn around each paragraph and callout (paragraphs: p1-p5 and callouts: c1-c4).

Procedure and Equipment

After giving their informed consent, participants were randomly assigned to one of four groups (scrolling with callouts; scrolling without callouts; pagination with callouts; pagination without callouts) and were requested to read the text presented on the screen. We recorded their eye movements during both tasks with a table-mounted eye tracking system with 120 Hz sampling rate that consisted of a 22-inch monitor with integrated infrared camera (SensoMotoric Instruments, Berlin, Germany). Each session lasted on average 10 minutes.

Finally, participants were asked to complete a text recall test that contained questions testing deep and shallow processing of the presented material. Deep processing scale consisted of 12 multiple-choice questions regarding selected facts described in the text. Participants could answer four out of these queries on the basis of material presented in the callouts only. Participants were also presented with 13 words and asked if they were present in the text. Four of these terms were the exact words appearing in the text and five were synonyms. Those two types of questions served as a measure of deep processing or ‘the complete model’ (Zwaan, Radvansky, 1998). To measure shallow processing or the ‘current model’, we used three words that were visually similar but different in meaning and one word that was both visually and semantically different, compared to the words from the text.

The time to complete both the reading task and the questionnaire was unlimited. Due to the differences in range of scales, we standardized the results, but the standardization procedure did not affect the direction or effect size.

Data Analysis

Eye-tracking data were extracted using BeGaze software (SensoMotoric Instruments, Berlin, Germany) with dispersion-based event detection algorithm that is suitable for 120 Hz sampling rate (Holmqvist et al., 2011). Fixation was defined with minimum duration of 80 ms to remove fixations with low durations and maximum dispersion of 100 pixels. Next, we drew areas of interest 1) around each paragraph and each callout and 2) around all paragraphs and all callouts to accommodate two different analyses. Finally, we analyzed four eye-tracking indices (glance count, glance duration and fixation count) with the SPSS Statistics package.

We defined glance count as the number of saccades that entered a particular area of interest, and glance duration as the sum of all fixation and saccade durations within that area including the entering saccade. Fixation count was the number of fixations that hit the area across the duration of the experiment. We also analyzed the number of revisits (defined as glance count – 1) between all paragraphs together and all callouts. The remaining statistics were calculated for each paragraph and callouts separately. Definitions of the eye-tracking indices are in accordance with the BeGaze Manual (Senso Motoric Instruments, 2009).

RESULTS

The results are divided in two subsections: the first part discusses the issue of text processing based on the questionnaire data, which is divided according to the levels of text comprehension consistent with Craik and Lockhart (1972). We take into account two extreme processing levels: shallow and deep, which correspond to the ‘current’ and ‘complete’ levels in their model. The second subsection addresses the issue of reading effectiveness based on the eye-tracking data.

TEXT PROCESSING

Reading a text involves several cognitive processes such as deduction and linking newly acquired information with our current knowledge (Craik, Lockhart, 1972; Zwaan, Radvansky, 1998). The more intense these processes are and the more effort one puts into text comprehension, the easier it becomes for one to remember it. By using a text recall questionnaire, we examined the influence of text visualization on the different levels of text processing.

Deep Processing

To examine the relationship between text recall in different types of questions and various presentation conditions, we calculated a 3-way Mixed Model Repeated Measures Analysis of Variance (ANOVA) 3 (question type: multiple choice questions versus synonyms versus target words) x 2 (text visualization condition: pagination versus scrolling) x 2 (text visualization condition:

callouts versus no callouts). We conducted the analysis on standardized data to avoid the effect of different scales for each question type. A significant interaction effect emerged between scrolling and callout factors ($F(1,35) = 6.35$; $p = 0.016$; $\eta^2=0.15$, see Figure 2). Post-hoc comparisons revealed that this interaction arose from the differences on the level of performance in the scrolling condition between no callout ($M = -0.51$, $SE = 0.25$) and callout ($M = 0.31$, $SE = 0.22$; $F(1,35) = 6.00$; $p = 0.019$; $\eta^2= 0.15$) presentation modes (see Figure 2). This effect suggests that if the text is scrolled, callouts increase the number of correctly recalled words. When the text does not contain callouts a significant difference arises between paginated ($M = 0.24$; $SE = 0.21$) and scrolled text ($M = -0.51$; $SE = 0.25$), $F(1,35) = 5.30$, $p = 0.027$; $\eta^2=0.13$.

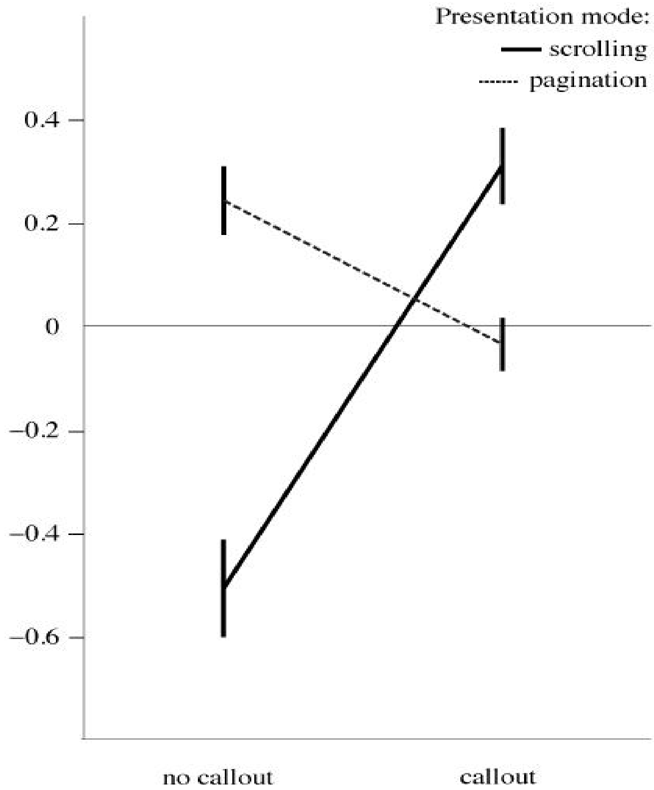

Figure 2. Standardized proportion of correctly recalled words with error bars representing standard error of the mean (*SE*). Main effect of condition suggests that in the pagination format, participants had significantly better performance. Post hoc analysis suggests that in the scrolling condition, callouts increase the number of correctly recalled words.

Shallow Processing

Next, we assessed the influence of text visualization on shallow text processing with a 2 (the question type: similar words versus new targets) x 2 (text visualization condition: scrolling versus pagination) x 2 (text visualization condition: callout versus no callout) Mixed Model Repeated Measures ANOVA. We saw a significant main effect of text presentation mode on words from the questionnaire falsely recognized as present in the text ($F (1,38) = 8.72$; $p = 0.005$; $\eta^2 = 0.19$). The mean number of falsely recalled words in the scrolling condition was significantly lower than in the paginated condition ($M = -0.38$, $SE = 0.17$ versus $M = 0.30$, $SE = 0.16$). The results suggest that in the context of shallow processing, text pagination leads to an increase in false words recall.

EYE-TRACKING DATA

The measures of the eye-tracking data from the main text (fixation count, glance count, glance duration) were analyzed with a 2 (text visualization condition: scrolling versus pagination) x 2 (text visualization condition: callouts versus no callouts) x 5 (the paragraph sequence: first versus second versus third versus fourth versus fifth) Repeated Measures Analysis of Variance (ANOVA). We chose glance count, glance duration and fixation count because we were particularly interested in the duration of time spent reading the body of the text. Please see the Methods section for more details on the event detection algorithm and definitions of eye-tracking indices.

Glance Count

The analysis of glance count revealed the main effect of the presentation mode, $F (1,38) = 16.61$; $p = 0.000$; $\eta^2 = 0.30$. Reading the text in the scrolling condition required more glances ($M = 11.09$; $SE = 0.78$) than in the paginated mode ($M = 6.56$; $SE = 0.79$). We also observed an interaction between text presentation mode and paragraph sequence, $F (4,152) = 5.25$; $p = 0.003$; $\eta^2 = 0.12$. The planned comparisons analysis showed a higher glance count in the scrolling condition compared to pagination in each paragraph except for the last one, which was the shortest of all the other paragraphs and also lacked a callout (see Figure 3).

Glance Duration

We found a main effect of glance duration on the presentation mode: participants who scrolled the text spent more time reading than those who saw the same text in a paginated form ($M = 25490.07$ ms; $SE = 1928.33$ ms and $M = 19773.91$ ms; $SE = 1946.10$ ms, accordingly), $F (1,38) = 4.35$; $p = 0.044$, $\eta^2 = 0.10$. We also found a significant effect of the paragraph sequence, $F (4,152) = 55.05$; $p = 0.000$; $\eta^2 = 0.59$, indicating that glance duration declined with each consecutive paragraph (in the first part of the text it was $M = 33195.38$ ms, while in the fifth paragraph it reached $M = 9887.75$ ms).

Fixation Count

We found no effect of experimental manipulation on the fixation count. Regardless of the presence of callouts or pagination, participants had similar number of fixations

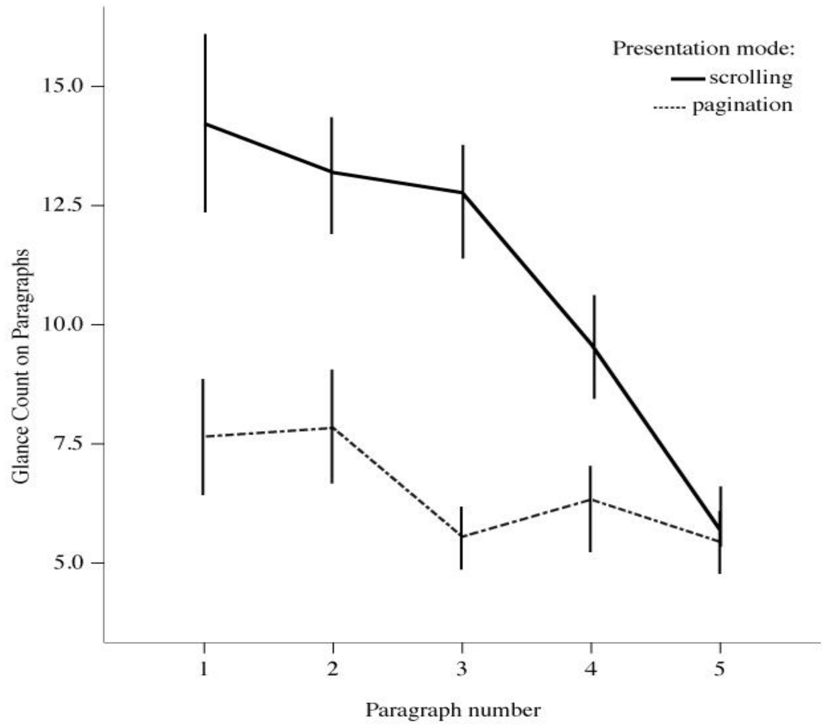

Figure 3. Glance count analysis. ANOVA revealed a decreasing number of glances by the end of the text, which was particularly visible in the scrolling condition.

during the reading. However, there was a main effect of paragraph sequence, showing that the number of fixations decreased with subsequent sections of the text ($F (4,152) = 61.27$; $p = 0.000$; $\eta^2= 0.62$). This result is aligned with the glance count and glance duration analysis.

Revisits

The 2 (text visualization condition: scrolling versus pagination) x 2 (target position: callouts versus body text) Repeated Measures Analysis of Variance was run on the number of revisits between the body of the text and the callouts. In contrast to previously described analysis, we compared the number of transitions participants made between all callouts and the whole text. The analysis showed a significant main effect of the presentation mode, $F (1,40) = 17.86$; $p = 0.000$; $\eta^2= 0.31$ (the mean number of revisits to the body of the text in the scrolling condition was $M = 5.82$; $SE = 0.46$; in the pagination condition $M = 3.06$; $SE = 0.46$). We also found a significant interaction: $F (1,40) = 10.17$; $p = 0.003$; $\eta^2= 0.20$ (see Figure 4). Further analysis revealed that the interaction

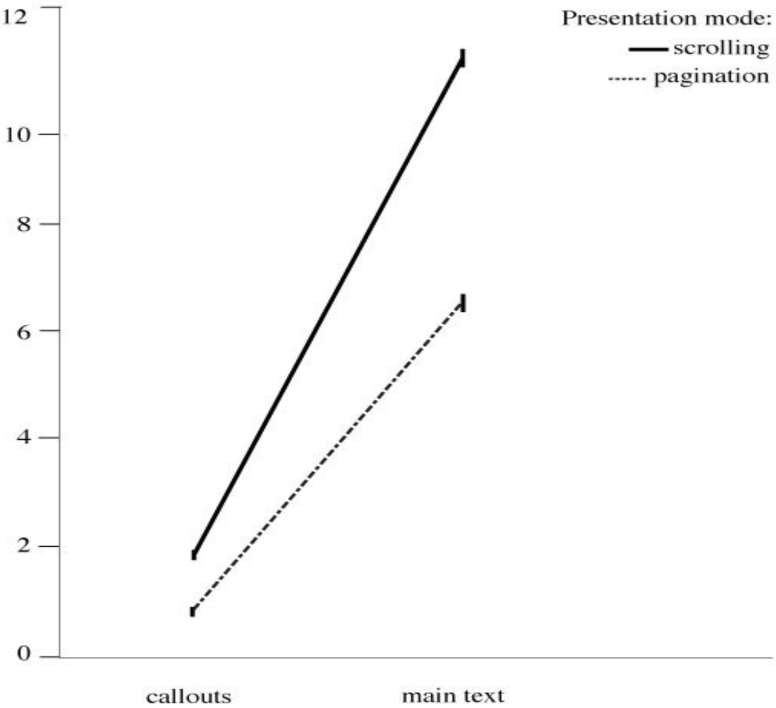

Figure 4. Significant interaction emerged in the number of transitions between the whole text and callouts across experimental conditions. Significantly more revisits were made when the text had to be scrolled.

emerged from significantly higher number of revisits to the main text when readers had to scroll the text, ($F(1,40) = 17.76$; $p = 0.000$; $\eta^2 = 0.31$).

DISCUSSION AND FURTHER RESEARCH

The goal of this study was to systematically investigate the influence of the presentation format of intellectually challenging material on information processing, quantified with eye movements, and recall, which we assessed with a test. We observed that an increased overall reading time in the scrolling condition did not translate into a deeper understanding of the text. The results showed that whenever participants had to scroll through the text, their results in the recall test were significantly lower in comparison to the pagination condition. This result is in line with Kolers et al. (1981) and Schwarz et al. (1983), who argued that pagination helps readers focus on the gist of the text. Our results showed that remembering information location could be used as mnemotechnic aid, which could explain the better performance on the recall test.

The analysis of glance count further indicated that participants in the scrolling condition were making more eye movements across the screen. Based on these results, we argue that although participants spent more time and made more transitions between paragraphs, they were not able to process the information correctly, when reading a scrolled text. We also found that callouts increased the performance in the scrolling condition, possibly because they help in dividing the material into visually distinct parts. The importance of spatial location for later recall was demonstrated in previous research (Kennedy, 1992; Le Bigot et al., 2009; Le Bigot et al., 2011).

We observed that in the scrolling condition, participants made more transitions between the main body of the text and callouts, compared to the paginated mode. This suggests that either callouts were distracting from the main text or served as an aid in comprehension. We observed a significant increase in deep processing in the scrolling condition with callouts, which indicates that the latter explanation is more probable. Therefore, we conclude that presenting text with callouts is beneficial for comprehension in case of less efficient formats, such as scrolling.

Further explanation of the results examines the possible influence of the working memory capacity on reading efficacy (Sanchez, Wiley, 2009). Differences in text recall between groups might be related to the fact that working memory was differently engaged in reading of the text presented on one screen, compared to the one divided into several screens. Paginated version of the text might have facilitated more effective, location-based coding of information, whereas in the scrolling condition, participants had to divide the content into smaller 'chunks' themselves, and the ability to do so might have depended on their cognitive skills, such as working memory. For example, Chein and Morrison's (2010) study indicates that there is a link between working memory and reading comprehension. Since in this experiment we did not measure working memory capacity, further research is planned to investigate its influence on text processing, especially in the case of people with temporary or stable working memory impairments. It is possible that making special adjustments such as callouts or pagination would increase the understanding of material that requires sustained attention over a period of time, for example instructions, policies or legal agreements.

STUDY LIMITATIONS

There are limitations to this study. First, the text used in this experiment was described as moderately challenging and not very long by participants. Therefore, we argue that the above-described implications could be reinforced if a more difficult and longer text were used. The fact that the callouts were exactly of the same content as excerpts of the main text could also have influenced the test validity. Participants who read the same sentence twice, could have benefitted from the presence of callouts because they got more familiar with the content of the presented stimuli.

Furthermore, due to the fact that data collection took place during the Brain Weekend, participants were not a homogenous group in terms of age, cognitive abilities and computer skills, which might have further influenced the obtained results. In the consecutive study we plan to use a more complex text and run additional test regarding the WMC capacity of participants.

Received April 24, 2014

REFERENCES

ATKINSON, R.C., SHIFFRIN, R.M., 1971, *The control of short-term memory.* Institute for Mathematical Studies in the Social Sciences, Stanford University.

BAKER, J.R., 2003, The impact of paging vs. scrolling on reading online text passages. *Usability News,* 5, 1, BCS.

BOJKO, A., 2006, Using eye tracking to compare web page designs: A case study. *Journal of Usability Studies*, 1, 3, 112-120.

BOLTER J., 1991, *Writing space: The computer, hypertext, and the history of writing*. New Jersey: Lawrence Erlbaum.

BOLTER J., 2001, *Writing space: The computer, hypertext, and the remediation of print.* Second edition. New Jersey: Lawrence Erlbaum.

BRINGHURST, R., 2005, *The elements of typographic style*. Vancouver: Hartley & Marks Publishers.

CRAIK, F.I., LOCKHART, R.S., 1972, Levels of processing. A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 11, 6, 671-684.

CHEIN, J.M., MORRISON, A.B., 2010, Expanding the mind's workspace: Training and transfer effects with a complex working memory span task. *Psychonomic Bulletin & Review*, 17, 2, 193-199.

DUCHOWSKI, A.T., 2003, *Eye tracking methodology: Theory and practice*. New York: Springer-Verlag.

DICARLO, J.J., ZOCCOLAN, D., RUST, N.C., 2012, How does the brain solve visual object recognition? *Neuron*, 73, 3, 415-434.

FELICI, J., 2003, *The complete manual of typography. A guide to setting perfect type*. San Francisco: Peachpit Press.

HOLMQVIST, K., WARTENBERG, C., 2005, The role of local design factors for newspaper reading behaviour – an eye-tracking perspective. *Lund University Cognitive Studies*, 1-21.

HOLMQVIST, K., NYSTRO, M., ANDERSSON, R., DEWHURST, R., JARODZKA, H., VEN DER WEIJER, J., 2011, *Eye tracking: A comprehensive guide methods and measures*. Oxford: Oxford University Press.

HOLMQVIST, K., HOLSANOVA, J., BARTHELSON, M., LUNDQVIST, D., 2003, *Reading or scanning? A study of newspaper and net paper reading*. In: J. Hyönä, R. Radach, H. Deubel (Eds.), *The mind's eye: Cognitive and applied aspects of eye movement research* (pp. 657-670). Elsevier.

JACOB, R.J.K., KARN, K.S., 2003, Eye tracking in human – computer interaction and usability research: Ready to deliver the promises. In: J. Hyönä, R. Radach, H. Deubel (Eds.), *The mind's eye: Cognitive and applied aspects of eye movement research* (pp. 573-605). Elsevier.

JUST, M.A., CARPENTER, P.A., 1976, Eye fixations and cognitive processes. *Cognitive Psychology*, 8, 4, 441-480.

KENNEDY, A., 1992, The spatial coding hypothesis. In: K. Rayner (Ed.), *Eye movements and visual cognition: Scene perception and reading* (pp.379-396). New York: Springer-Verlag.

KOLERS, P.A., DUCHNICKY, R.L., FERGUSON, D.C., 1981, Eye movement measurement of readability of CRT displays. *Human Factors*, 23, 5, 517-527.

LANDOW, G.P., 1992, *Hypertext: The convergence of contemporary critical theory and technology*. Baltimore: Johns Hopkins University Press.

LANDO, G.P., 1997, *Hypertext 2.0. Revised edition*. Baltimore: Johns Hopkins University Press.

LE BIGOT, N., PASSERAULT, J.M., OLIVE, T., 2009, Memory for words location in writing. *Psychological Research*, 73, 1, 89-97.

LE BIGOT, N., PASSERAULT, J.M., OLIVE, T., 2011, Implication of visuospatial and temporal information in memory for word location. *Journal of Cognitive Psychology*, 23, 4, 522-530.

LIU, Z., 2005, Reading behaviour in the digital environment: Changes in reading behaviour over the past ten years. *Journal of Documentation*, 61, 6, 700-712.

MANGEN, A., 2008, Hypertext fiction reading: Haptics and immersion, *Journal of Research in Reading*, 31, 4, 404-419.

MORKES, J., NIELSEN, J., 1997, Concise, scannable and objective: How to write for the web. http://www.useit.com/papers/webwriting/writing.html.

MUTER, P., 1996, Interface design and optimization of reading of continuous text. In: H. van Oostendorp, S. De Mul (Eds.), *Cognitive aspects of electronic text processing*. Norwood: Greenwood Publishing Group.

PANNASCH, S., HELMERT, J.R., VELICHKOVSKY, B.M., 2008, Eye tracking and usability research: An introduction to the special issue. *Journal of Eye Movement Research*, 2, 4, 1-4.

POOLE, A., BALL, L.J., 2005, Eye tracking in human-computer interaction and usability research:

Current status and future prospects. *Encyclopaedia of human computer interaction*, 211-219.

RAYNER, K., 1998, Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124, 3, 372-422.

RAYNER, K., 2009, Eye movements and attention in reading, scene perception, and visual search. *Quarterly Journal of Experimental Psychology*, 62, 8, 457-506.

ROTHKOPF, E.Z., 1971, Incidental memory for location of information in text. *Journal of Verbal Learning and Verbal Behavior*, 10, 6, 608-613.

SANCHEZ, C., WILEY, J., 2009, To scroll or not to scroll: Scrolling, working memory capacity, and comprehending complex texts. *Human Factors*, 51, 5 730-738.

SCHWARTZ, E., BELDIE, I.P., PASTOOR, S., 1983, A comparison of paging and scrolling for changing screen contents by inexperienced users. *Human Factors*, 25, 3, 279-282.

SCHWARTZ, M., 1995, *Guidelines for bias-free writing*. Bloomington: Indiana University Press.

SensoMotoric Instruments, 2009, BeGaze 2.3. Manual.

SHRESTHA, S., OWENS, J.W., 2008, Eye movement patterns on single and dual-column web pages. *Usability News*, 10, 1 0-6, BCS.

SHRESTHA, S., OWENS, J.W., 2009, Eye movement analysis of text-based web page layouts. *Usability News*, 11, 1, BCS.

SKŁODOWSKA-CURIE, M., 2009, *Autobiografia i wspomnienia o Piotrze Curie*. Warsaw: Dom Wydawniczo-Promocyjny GAL.

SPENCE, R., 2007, *Information visualization: Design for interaction*. New Jersey: Prentice Hall.

SPOOL, J.M., SCANLON, T., SCHROEDER, W., SNYDER, C., DEANGELO, T., 1997, *Web site usability: A designer's guide*. Burlington: Morgan Kaufmann Publishers.

ZAMBARBIERI, D., CARNIGLIA, E., ROBINO, C., 2008, Eye tracking analysis in reading online newspapers. *Journal of Eye Movement Research*, 2, 4, 1-8.

ZWAAN, R.A., RADVANSKY, G.A., 1998, Situation models in language comprehension and memory. *Psychological Bulletin*, 123, 2, 162-185.

SPÔSOB PREZENTÁCIE TEXTU A JEHO VPLYV NA EFEKTIVITU ČÍTANIA – ROLOVANIE VS. STRÁNKOVANIE

A. M. Wieczorek, Z. Kłyszejko, J. Sarzyńska, A. Szóstek, K. Chmiel, T. Soluch, A. Brzezicka

Súhrn: V posledných desaťročiach sa z internetu stal neustále sa rozvíjajúci a prekvitajúci zdroj informácií. Tento fenomén vyžaduje, aby sa zložité úseky textu prezentovali spôsobom, ktorý urýchli efektivitu ich spracovania. Štúdia predstavuje experiment, ktorý skúmal ako prezentácia textu ovplyvňuje efektivitu čítania a reprodukciu textu. Porovnali sme rôzne druhy prezentácie textu – rolovanie a stránkovanie, a to s a bez poznámok. Znovupoznanie prezentovaného textu sme merali pomocou znaovupoznávania slov. Z výsledkov získaných pomocou prístroja na sledovanie pohybu očí boli zrejmé rozdiely v efektivite čítania; konkrétne sme zistili, že rolovanie je náročnejšie na čas spracovania textu v porovnaní so stránkovaným textom. Naše zistenia podporujú tvrdenia o efektívnejšom spracovávaní stránkovaného textu. Táto forma prezentácie textu má silný vplyv na poznanie, čo by mali vziať do úvahy dizajnéri, ktorí vytvárajú prezentácie zložitých textov online.