An Experimental Approach in Conceptualizing Typographic Signals of Documents by Eight-Dot and Six-Dot Braille Code

Vassilios Argyropoulos[1], Aineias Martos[1,2], Georgios Kouroupetroglou[2], Sofia Chamonikolaou[1], and Magda Nikolaraizi[1]

[1] University of Thessaly, Department of Special Education, Volos, Greece
vassargi@uth.gr
[2] National and Kapodistrian University of Athens, Department of Informatics and Telecommunications, Athens, Greece
koupe@di.uoa.gr

Abstract. The main research aim of the present study focuses on issues of reading comprehension, when users with blindness receive typographic meta-data by touch through a braille display. Levels of reading comprehension are investigated by the use of 6-dot and 8-dot braille code in matched texts for the cases of bold and italic meta-data. The results indicated a slight superiority of the 8-dot braille code in reading time and scorings. The discussion considered the practical implications of the findings such as issues regarding education as well as the development of suitable design of tactile rendition of typographic signals through 6-dot or 8-dot braille code in favor of better perception and comprehension.

Keywords: typographic signals, 6-dot braille, 8-dot braille, braille display, blindness, document accessibility, assistive technology.

1 Introduction

This paper reports on the results from a series of experiments in the field of haptic representation of typographic meta-information or meta-data embedded in rich texts or documents. Similar attempts are emerging for incorporating typographic knowledge of documents into Text-to-Speech [1]. Typographic signals [2] is the information that readers get from the documents at the typographic layer which includes font (type, size, color, background color, etc.) and font style such as bold, italics, underline [3-4]. These attributes play a crucial role in comprehension. It seems that there is a plethora of semantics in applying the typographic layer. For example, in contrast to the tags introduced by the W3C for the bold and italic font styles [5], we have identified [6] the following eight different "labels" that the readers seem to use most frequently in order to semantically characterize text in "bold" and "italics (a total of 2,927 entities, of which 1,866 were occurrences of "bold" and 1,061 of "italics" were manually labelled in a

C. Stephanidis and M. Antona (Eds.): UAHCI/HCII 2014, Part II, LNCS 8514, pp. 83–92, 2014.

corpus of 2,000 articles of a Greek newspaper): emphasis, important / salient, basic block, quotation, note, title, list / numeration category and interview / dialogue.

The scope of this study is to investigate the rendition of typographic signaling in a haptic interface. This specific haptic representation relies on braille. In order to describe better the approach of this study it is important to distinguish some basic peculiarities between the embossed braille and the braille produced by a braille display. In embossed braille, titles, subtitles, headings and indentation are used almost in the same way as in print [2]. On the other hand, when braille is rendered by electronic devices such as braille displays, then readers normally use their working memory to store the words, text attributes and ideas [7]. Usually only underlined text is tagged in embossed braille [8], whereas braille displays use dots 7 and 8 to highlight a various number of points in the document. The lack of rendering typographic signals in embossed braille as well as the limited rendering of meta-information of documents through a braille display might have a negative impact on blind individuals' education and on their reading abilities as well [9].

Thus, the main research aim of the present study focuses on issues of reading comprehension, when blind users receive typographic meta-data (bold and italic) by touch through a braille display, i.e. an electro-mechanical device for displaying braille characters [10]. Levels of reading comprehension are investigated by the use of 6-dot braille and 8-dot braille code in matched texts. In essence, the research objectives of the present study are the following:

a. To compare the Overall Reading Time (ORT) required for each participant to read matched texts in 8-dot and 6-dot braille code,
b. To compare the average time required for each participant to answer comprehension questions in 8-dot and 6-dot braille code through matched texts, and
c. To compare the participants' Overall Scoring (OS) in answering comprehension questions in matched texts in 8-dot and 6-dot braille code respectively.

2 Method

2.1 Participants

In the present study, eight individuals (A, B… H) with blindness participated in a series of experiments using braille displays. All participants were good braillists, had no other additional disabilities and their age range was from 20 to 40 years (mean= 31.25, SD= 6.07).

2.2 The Experimental Design

The experimental design comprised two parts: the preliminary phase and the main research.

Preliminary Phase. The main prerequisite for this study was to determine the rendition of the typographic signals “bold” and “italic” in the 8-dot and 6-dot braille code respectively through a braille display.

Regarding the 6-dot braille code there are indicators (tags) in the Nemeth code which specify the presence of the typographic signals, i.e. bold letters are tagged by dots 4 and 6 and italics are tagged by dots 4, 5 and 6. Yet, the rendition of these specific typographic signals in the 8-dot braille code is not well established [11]. What is common so far in braille displays is the use of the dots 7 or 8 in the braille character cell, to indicate additional information, which is embedded in the document (e.g. a typographic signal of the text in use) [11]. Thus, in this preliminary phase, a number of tests were conducted by two blind users with a series of texts to choose the appropriate combination for the rendition of the typographic signals “bold” and “italic” in the 8-dot braille code through a braille display. Two rendition versions were tested in order to conclude which one was the best to apply (see Table 1). Also, there was a thought of a 3rd version of shifting the braille characters in the lower part of the 8-dot braille cell, indicating in this way either the bold or the italic typographic attribute, but at the end it was considered very complicated and eventually was excluded from the tests. The criterion for the best suited version in our case was the participants’ subjective evaluations regarding the element of familiarization, in conjunction with the time needed to go through the texts.

Table 1. Renditions of the typographic signals “bold” and “italic” in the 8-dot braille code

Version	Bold (word or phrase)	Italic (word or phrase)
1	rendition by raising constantly pins 7 and 8	rendition by raising pins 7 and 8 intermittently (i.e. at the first, middle and last letters of the word/phrase)
2	rendition by raising pin 8 only for the consonants in the word/phrase (the vowels were excluded as Greek the accent of the vowels is rendered by raising pin 8 in the 8-dot braille code [12]	rendition by raising pin 8 intermittently (i.e. at the first, middle and last letters of the word/phrase)

It was conjectured that Version 1 enabled the blind users to recognize faster and more accurately the typographic signals of bold and italic within the texts in 8-dot braille code. They highlighted the facilitating character of the bold rendition by the constant raised pins 7 and 8 throughout the whole word or phrase.

Moreover, all participants’ reading performances were timed. Version 1 occupied the best reading rate with the least errors. For the rendition of the typographic signals bold and italic in the 6-dot braille code, the researchers used the tags which are specified by Nemeth code (as mentioned in the Introduction section) with a slight modification.

They replaced dots 4 and 6 by dots 5 and 6, because the former constitutes the indicator for capitals in the 6 dot Greek Braille code.

Main Research. During the main research, each of the eight participants was invited to read through a braille display four expository texts and then asked to answer five comprehension questions for each text. All participants were given appropriate time to familiarize themselves with the use of a braille display.

There are two strands of texts; narrative and expository. Narrative texts facilitate students' reading comprehension because they have a structured schema and contain sequences that are easier to follow. On the other hand, expository texts contain information that may be unknown to the students or may require the activation of their prior knowledge while they have a more abstract structure [13-14]. Since the age range of the participants was from 20 years to 40 years, it was decided that expository texts would best fit to the needs of the present study.

As mentioned above, the participants' ability to comprehend a text was assessed through four expository texts. The number of words in each text ranged from 115 to 179 words. In specific, two pairs of texts were selected which were matched on three factors: a) grade, b) number of typographic signals (each text included three words/phrases in bold and three words/phrases in italic), and c) content. Thus, we have selected two texts with general informative content without any technical terms (179 words and 165 words respectively) and two texts with scientific content and mathematical terminology (115 words and 119 words respectively). The first text of the first pair was rendered by 6-dot braille code and the second text of the same pair was rendered by 8-dot braille code. The rendition of the typographic signals "bold" and "italic" in the 8-dot braille code followed Version 1 (Table 1), whereas regarding the 6-dot braille code, the researchers adopted the indicators of the Nemeth code with a slight modification as mentioned in the preliminary phase [i.e. dots (4, 5) for bold and dots (4, 5, 6) for italic]. Finally, all the selected texts were in fact extracts from textbooks used in Greek public high schools.

Five comprehension questions corresponded to each text. Participants were instructed to read each text aloud or silently through a braille display and, when finished, the researchers asked the participant each question orally. Participants were allowed to go back to the passage in order to search for the right answer when needed. The questions corresponded to the three types of the reading comprehension question taxonomy of Pearson and Johnson [15]: textually explicit, textually implicit and scriptually implicit. Textually explicit questions require no inference and the answer is literally mentioned in the passage [15]. Textually implicit questions require inference and the activation of background knowledge. Scriptually implicit questions are based on the background knowledge of the reader who is asked to make inferences about the general meaning of the text and rely on his background knowledge in order to grasp the meaning [16].

The researchers constructed five questions for each text which corresponded to the three types of reading comprehension questions. Specifically, the first three were textually explicit questions, the fourth question was textually implicit, and the fifth question was scriptually implicit. All correct responses were scored with 1 while all incorrect responses were scored with 0. The scores that participants could achieve for all texts were from 0 up to 20.

3 Results

3.1 First Research Objective: The Overall Reading Time

Figure 1 provides a description of the ORT that the participants' dedicated while reading the general informative text (G) by the 8-dot and the 6-dot braille code. Initial examination of the data in the graph shows that all participants dedicated more time to read the text by the 8-dot (8D) braille code (min.ORT8DG=7.2 minutes & max.ORT8DG=13.57 minutes) rather than by the 6-dot (6D) braille code (min.ORT6DG=4.08 minutes & max.ORT6DG=11.23minutes). Only participant F seemed to spend more time when reading by the 6-dot braille (9.28 minutes) compared to the 8-dot braille code (8.1 minutes).

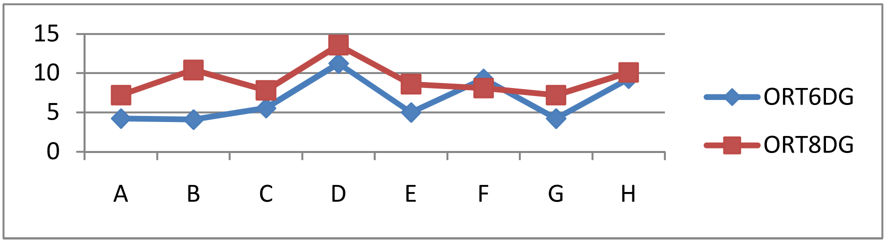

Fig. 1. Overall reading time (ORT) for general informative text (G) in the 8-dot (8D) and the 6-dot braille code (6D)

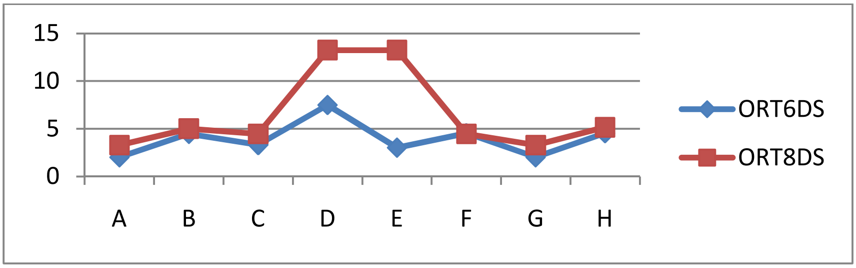

Fig. 2. Overall reading time (ORT) for scientific text (S) in the 8-dot (8D) and the 6-dot braille code (6D)

The same analysis took place regarding the texts with the scientific content. In particular, all participants seemed to spend more time to read the scientific text (S) by the 8-dot (8D) braille code (min.ORT8DS=3.3minutes & max.ORT8DS= 13.25minutes) rather than by the 6-dot (6D) braille code (min.ORT6DS=2.01minutes & max.ORT6DS=4.54 minutes) (Figure 2).

3.2 Second Research Objective: The Average Answering Time

In contrast to the above figures (1 & 2) which provide a "whole picture" of the participants' reading time through the texts by both braille codes, the second measure actually focuses on the participants' average amount of time dedicated to listening the comprehension questions, searching the answers in the text through the braille display as well as answering them. Figure 3 shows that the situation here is the other way round. In specific, the average time (AVER) that the participants spent to answer the comprehension questions concerning the texts with the general informative content (G) in the 8-dot (8D) braille code was less than that in the 6-dot (6D) braille code (min.AVER8DG=0.63 minutes & max.AVER8DG =1.63 minutes vs min.AVER6DG= 0.83minutes & max.AVER 6DG=3.93 minutes) (Figure 3).

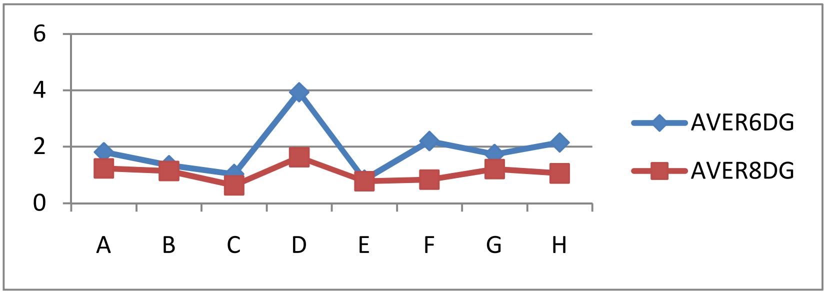

Fig. 3. Average time (AVER) in answering comprehension questions concerning the texts with general informative content (G) in the 6-dot (6D) and 8-dot (8D) braille code

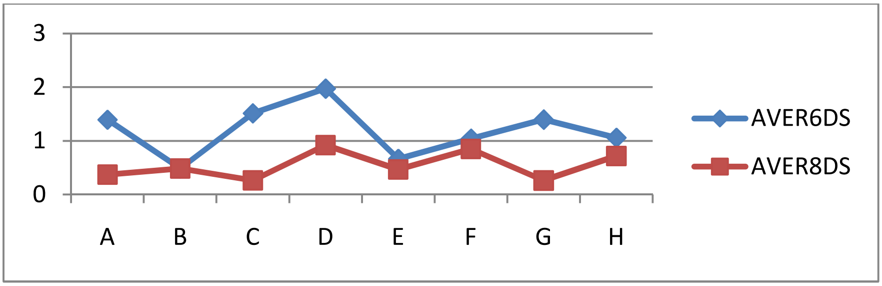

Fig. 4. Average time (AVER) in answering comprehension questions concerning the texts with scientific content (S) in the 8-dot (8D) braille code

The same picture came up regarding the texts with scientific content. The average time (AVER) for the participants to answer the comprehension questions regarding the texts with the scientific content (S) in the 8-dot (8D) braille code was less than that in the 6-dot (6D) braille code (min.AVER8DS=0.26 minutes & max.AVER8DS =0.92 minutes vs min.AVER6DS=0.49 minutes & max.AVER6DS=1.97 minutes) (Figure 4).

3.3 Third Research Objective: The Overall Scoring

The third measure was based on the overall scoring (OS) in answering the comprehension questions. Figure 5 shows the participants' overall scorings in the general informative (G) texts. It seems that they got similar results with almost equivalent values in averages (AVEROS8DG=3.63 & AVEROS6DG=3) and standard deviations (STDOS8DG=2 & STDOS6DG=1.69). It is worth mentioning the slight superiority of the 8-dot braille code in answering the 4th question (4Q) which was textually implicit (4Q8DG=5 vs 4Q6DG=2) and the 5th question (5Q) which was scripturally implicit (5Q8DG=6 vs 5Q6DG=4).

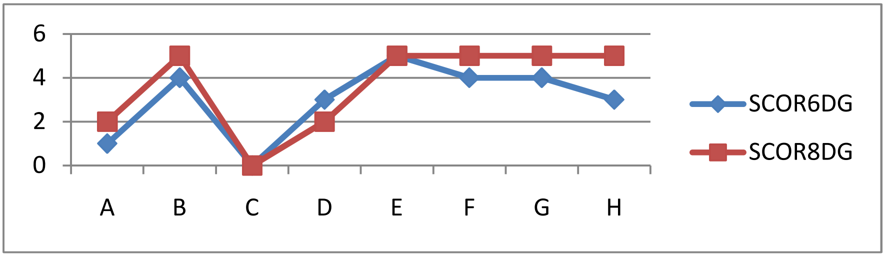

Fig. 5. Overall scorings (OS) in answering comprehension questions concerning the texts with general informative content (G) in the 6-dot (6D) and 8-dot (8D) braille code

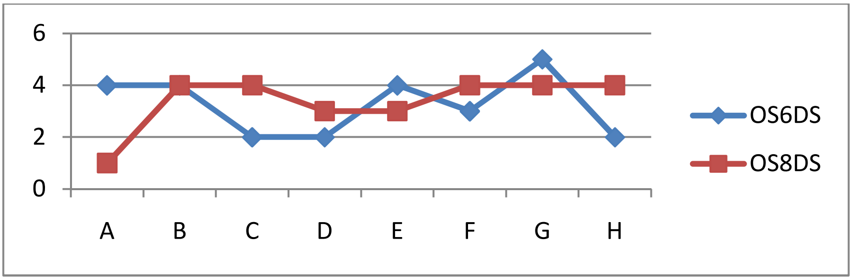

Fig. 6. Overall scorings (OS) in answering comprehension questions concerning the texts with scientific content (S) in the 6-dot (6D) and 8-dot (8D) braille code

Figure 6 provides information about the participants' overall scorings in the scientific (S) texts. It could be argued that the participants' OSs when using 8-dot (8D) and 6-dot braille code (6D) were equivalent since they had the same average (AVEROS8DS=3.38 & AVEROS6DS=3.25) and the same standard deviations (STDOS8DS=1.06 & STDOS6DS=1.16). It is worth mentioning that the participants' biggest convergence in scoring was in the 1st comprehension question (1Q), which was textually explicit (1Q8DS=8 & 1Q6DS=7), whereas the biggest divergence took place on the 4th comprehension question (4Q) which was textually implicit (4Q8DS=7 & 4Q6DS=3).

4 Discussion and Conclusions

This paper addresses issues of reading comprehension, when blind users receive typographic meta-data (bold and italic) by touch through a braille display in 6-dot braille and 8-dot braille code in matched texts (general content and scientific content).

Based on the results, it was found that participants needed more time to read the texts (general and scientific) in the 8-dot braille code compared to the 6-dot braille; on the contrary, the participants spent, on average, less time to detect and answer the comprehension questions in the 8-dot braille code compared to the 6-dot braille. A "snapshot" of the above is provided in Table 2 and refers to the first two research objectives of the study (ORT and the average time that every participant needed to answer comprehension questions).

Table 2. Maximum and minimum values of Overall Reading Times (ORT) and Averages

	6DG		8DG	6DS		8DS
ORT(min)						
Min. value	4.08	<	7.2	2.01	<	3.3
Max. value	11.23	<	13.57	4.54	<<	13.25
AVER(min)						
Min. value	0.83	>	0.63	0.49	>	0.26
Max. value	3.93	>>	1.63	1.97	>>	0.92

It may be argued that the participants needed more time to read the different types of texts (G and S) in the 8-dot braille code (in some case the ORT was double or triple the corresponding ORT in the 6-dot, see Table 2), because individuals with blindness in Greece are not familiarized with 8-dot braille, in addition that very little research has been conducted in this area [12]. What is very interesting though, is the fact that the participants needed less time to answer the comprehension questions in 8-dot braille. This finding might be attributed to the fact that the participants' tactile movements on the 8-dot cell was more sophisticated compared to the 6-dot braille and as a result their attention was more intense in the first case. In turn, this elaborating process – when using the 8-dot braille code - might enhance the participants' cognitive operations of reading which take place in "working memory". "Working memory" describes the cognitive work called for by thinking tasks at the same time that it keeps information fresh in current memory [7]. Hence, it may be argued that the participants' working memory functioned more effectively when they were dealing with the 8-dot braille code and for this they spent less time - on average - to answer the comprehension questions.

The third research objective dealt with the participants' overall scoring (OS). It seems that the participants' performances in both braille codes were equivalent. Nevertheless, it is worth mentioning that they managed to get slightly better scores in the implicit questions (textually and scriptually implicit questions require an inferential answer, a response that is not literally or explicitly mentioned in the text) when they were reading through the 8-dot braille code in both general and scientific texts (also see Figures 5 & 6). It may be argued that this finding empowers the above reasoning about working memory.

Finally, further investigation is needed to choose the most appropriate braille indicators in order to represent typographic signals. Based on the results of this study, although marking with dots 7 and 8 was perceived as a good representation method in the 8-dot braille code for bold and italic, it remains quite limited since no other typographic signal can be rendered. The focus of relevant studies should put emphasis a. on the educational implications of the results, and b. on the development of a suitable design of tactile rendition of typographic signals through six or eight-dot braille code in favor of blind users' better perception and comprehension.

Acknowledgements. This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) under the Research Funding Project: "THALIS-University of Macedonia- KAIKOS: Audio and Tactile Access to Knowledge for Individuals with Visual Impairments", MIS 380442

References

1. Kouroupetroglou, G.: Incorporating Typographic, Logical and Layout Knowledge of Documents into Text-to-Speech. In: Proc. of the 12th European Conference on Assistive Technologies (AAATE), Vilamoura, Portugal, September 19-22, pp. 708–713. IOS Press (2013), doi:10.3233/978-1-61499-304-9-708
2. Lorch, R.F.: Text-Signaling Devices and Their Effects on Reading and Memory Processes. Educational Psychology Review 1, 209–234 (1989)
3. Kouroupetroglou, G., Tsonos, D.: Multimodal Accessibility of Documents. In: Pinder, S. (ed.) Advances in Human-Computer Interaction, I-Tech Education and Publishing, Vienna, pp. 451–470 (2008)
4. Tsonos, D., Kouroupetroglou, G.: Modeling Reader's Emotional State Response on Document's Typographic Elements. In: Advances in Human-Computer Interaction 2011, Article ID 206983, pp. 1–18 (2011), doi:10.1155/2011/2069832011
5. `http://www.w3.org/International/questions/qa-b-and-i-tags`
6. Fourli-Kartsouni, F., Slavakis, K., Kouroupetroglou, G., Theodoridis, S.: A Bayesian Network Approach to Semantic Labelling of Text Formatting in XML Corpora of Documents. In: Stephanidis, C. (ed.) HCI 2007. LNCS, vol. 4556, pp. 299–308. Springer, Heidelberg (2007)
7. Cohen, H., Scherzer, P., Viau, R., Voss, P., Lepore, F.: Working memory for braille is shaped by experience. Communicative & Integrative Biology 4(2), 227–229 (2011)

8. Braille Formats, Principles of Print-to-Braille Transcription, The Braille Authority of North America (2011)
9. Cheryl-Kamei, H.: Creative typesets require innovative solutions: A study of differences in braille indicators. PhD thesis, Department of Special Education, Rehabilitation and School Psychology, The University of Arizona (2008)
10. Cook, A., Polgar, J.M.: Essentials of Assistive Technologies. Elsevier, St. Louis (2012)
11. Dixon, J.: Eight-dot Braille. A Position Statement of the Braille Authority of North America (2007), http://www.brailleauthority.org/eightdot/eightdot.html
12. Kacorri, H., Kouroupetroglou, G.: Design and Developing Methodology for 8-dot Braille Code Systems. In: Stephanidis, C., Antona, M. (eds.) UAHCI 2013, Part III. LNCS, vol. 8011, pp. 331–340. Springer, Heidelberg (2013)
13. Diakidou, I.-A., Stylianou, P., Karefillidou, C., Papageorgiou, P.: The relationship between listening and reading comprehension of different types of text at increasing grade levels. Reading Psychology 26, 55–80 (2005)
14. Horiba, Y.: Reader control in reading: Effects of language competence, text type and task. Discourse Processes 29, 223–267 (2000)
15. Pearson, P.D., Johnson, D.: Teaching reading comprehension. Rinehart & Winston, New York (1978)
16. DuBravec, S., Dale, M.: Reader question formation as a tool for measuring comprehension: narrative and expository textual inferences in a second language. Journal of Research in Reading 25, 217–231 (2002)