Working Paper Series
ISSN 1177-777X

REVIEWING THE UNDERSTANDING OF THE EFFECTS OF SPACING ON CHILDREN'S EYE MOVEMENTS FOR ON-SCREEN READING

Nicholas Vanderschantz

Working Paper: 06/2008
April 2008

Department of Computer Science
The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Reviewing the Understanding of the Effects of Spacing on Children's Eye Movements for On-Screen Reading

Nicholas Vanderschantz

Department of Computer Science
University of Waikato
Hamilton, New Zealand
Telephone +64 7 838 4652

vtwoz@cs.waikato.ac.nz

ABSTRACT

This paper endeavors to consolidate current knowledge and empirical research concerning the use of typography for children's on-screen reading. This paper is not intended as a full literature review but attempts to raise awareness of the areas required for future investigation. This evaluation indicates a significant gap in the literature of children's on-screen reading and proposes a need for further investigations in typographical spacing. These future studies need to objectively consider children's eye movements and the effect of screen based text presentation on children's comprehension.

Categories and Subject Descriptors

H.5.5 [**User Interfaces**]: Screen Design (text), Theory & Methods, User Centered Design

H.1.2 [**User/Machine System**]: Human information processing

General Terms

Design, Human Factors, Theory

Keywords

Keywords are your own designated keywords.

1. INTRODUCTION

The nature of education and childhood today entails that children will encounter on-screen typography and screen based learning opportunities in both formal education and daily recreational pursuits. Children interact with on-screen text through reading in video & computer games, television, and the use of computer based multi-media, such as screen based books & the internet. It seems clear then that research which encourages best practices for the design of this material for children should be expedited.

Readability and legibility of text is affected by many variables, each of which can not be investigated within a vacuum. When considering typography for the screen the researcher must understand the reciprocal results of adjusting one variable compared to another. Empirical research has investigated typeface style, size and line length in depth. Typographical spacing, in the form of line spacing, word and letter spacing as well as margin and separation, however, has had relatively less investigation for either screen or print.

While the effects of typeface size, typeface choice, justification, colour and luminosity contrasts are highly important factors within the investigation of typography for the screen, these are considered outside the scope of this paper. Spacing is pursued as requiring investigation by this writer because it is believed that children's eye movements are less developed than adults and are more prone to reading errors and distractions caused by poorly spaced text presentation.

This paper attempts to distill the current knowledge in this area and indicate the gaps in the empirical studies to date. This research flows from investigation carried out by the writer in progress towards an MCGD which investigated the use of on-screen typography for children's comprehension. [1]

1.1 Motivation

Little research is available for comprehensive design direction for the creation of well formed typography for children's on-screen reading material. Dyson [2] states that there has been significant research into the legibility of print and the typographic considerations for effective reading in print. Dyson continues by discussing the classical reading psychology work of Tinker (1963, 1965), Zachrisson (1965), and Spencer (1968) and the more recent investigations for instructional text of Hartley (1994). Much of the work sited by Dyson discusses the results of adults' reading in print. The work of Watts & Nisbet [3] is one of the most concise discussions of children's text legibility for print on record. These works, though important in empirically analyzing the legibility of typographic variables of print for adults' and children's reading, do little to shed light on the specific problem of children's reading from screen.

Dillon [4] and Dyson & Kipping [5] point out that the empirical investigations of typographical issues related to reading in print remain unduplicated for the screen. Dillon [4], states that early studies of screen based reading compared and contrasted reading in print vs reading on screen and typographic assumptions for print were carried forth. Dillon continues to discuss the work of Creed et al [6] as indicating that when reading from screen compared to print, even when all variables are replicated, reading differences in each media can be found. The rapid development in technology and the large disparity in testing methods has rendered much of this research questionable and uncertain. It is however important for this knowledge to be discussed and future studies to be directed by these.

2. EYE MOVEMENTS IN READING

Much has been known about eye movements in reading of print since the early (1908) work of Huey [7] and his contemporaries. Movements of the eye are affected by both contextual and typographic variables. These variables can increase fixation duration and shorten saccade length, whilst increasing the frequency of saccadic regressions. Typographic variables such as typeface, line length, and spacing all appear to influence eye movements. [8]

2.1 Saccade

Saccades are fast, frequent eye movements of varied lengths which continuously occur when a person reads, looks at a scene or searches for an object. A saccade is separated by a fixation which is when the eye remains relatively still for about 200-300 milliseconds. The purpose of the saccade is to move the eye along the line of text that is being read; therefore, bringing a new section of text into the *fovea,* the central two degrees of vision, to enable the text to be fixated and processed. [8]

According to Matin [9], visual input is reduced to a point where no information is processed during a saccade; this is known as saccadic suppression. According to Rayner [8], Uttal & Smith in 1968, showed that saccadic suppression is caused by the eyes moving too quickly across the printed information, causing this information to become blurred.

English is written and read, left to right, thus the majority of saccades are forward movements. However, about 10–15% of all saccades are regressive or backward eye movements. When a reader struggles to comprehend a word, short within-word regressive saccades have been found; whereas, when a reader is struggling with a passage of text, or a line of text, up to 10 letter-space-equivalent regressions can occur. It is believed that competent readers are able to accurately move the eyes back to the text which caused issues, whereas, poorer readers backtrack less efficiently. [8]

2.2 Fixation

Fixations are the periods between saccades where the eyes are virtually motionless. It is during this time, that textual information is processed. Fixations occur 5-7 letter spaces into a word and do not tend to happen in the blank spaces between words or sentences. Adults make approximately four fixations per second in most reading conditions, with fixations lasting about 200-250ms. Not all words are fixated. [10]

During a fixation, the visual material that the eye processes, is divided into three distinct regions of the visual field: *foveal, parafoveal, and peripheral*. The amount of information that can be taken in within this visual field is described in the literature by many names; “span of apprehension”, “visual span” and the “perceptual window”. [10]

During a fixation, the fovea is the central two degrees of vision, the parafovea the five degrees either side of the fovea, and the peripheral is the further extension from the parafovea. The majority of visual information is processed and fixated in the foveal region. Whilst fixated, the eye can also take in a small amount of information in the parafoveal region, such as small function words which are often very short. Very little is able to be processed in the peripheral. [8]

Fixation time is dependant upon the complexity of the information to be processed. Fixation time is affected by both the contextual and visual complexity of the word being fixated. Peripheral preview is the term used to describe the information acquired from words preceding the fixated word. Peripheral preview can assist with reducing processing requirements of the fixated word. This in turn, reduces the fixation and potentially improves reading speed. Therefore, it can be assumed that when a previous fixation is a long distance from the current fixation, less information will have been gleaned from the previous fixation, than if said fixation had been closer. [11]

It is believed that as word length increases, the probability of fixating on such a word, increases. Rayner further discusses the work of Rayner & McConkie, 1976, who showed that 2-3 letter words are fixated approximately 25% of the time, compared to longer words of 8 letters and more, which are always fixated and at times more than once.

Fixations at the beginning and end of lines, also fall within the word that is toward the beginning or end of said line. Fixations often do not fall at the very beginning or end of a word. Readers, therefore, often make small corrective movements to the left on a return sweep, in an effort to find the first *Optimal Viewing Position* of the next line. Rayner [8], outlines the findings of Heller and Rayner; whereby, the first fixation on a line tends to be longer than other fixations, while the last is often shorter. Abrams & Zuber, according to Rayner [7], have shown that readers do not fixate in the blank spaces between words and sentences.

It is believed by some theorists, that eye movements and saccade programming are determined by the length of upcoming words. Low-level visual processes in the parafovea and peripheral, analyse the text ahead, in order to detect the length of upcoming words by the spaces that segregate these. [12]

Finally, it is of note, eye movements differ for reading aloud and reading silently. Text read aloud by the reader, or read along with narration, results in longer fixations than the same text read silently. Levy-Schoen’s research is discussed by Rayner [8]; whereby, experiments of reading aloud, have shown that readers make many fixations in which the eyes appear to be holding in place, in order not to get too far ahead of the voice.

2.3 Developmental Changes

It is well established, that there are trends in developmental changes in eye movements during reading. In 1922, Buswell, according to Rayner [8], discussed how increases in reading skill resulted in decreases of fixation duration, saccade length increases and decreases to the number of fixations, all occurring while frequency of regressions decrease.

Rayner [7], further discusses the 1991 research of McConkie et al, who examined children's eye movement behaviour and found that compared to adults, the children had more variability in their eye movement patterns. Interestingly, McConkie's research also showed that children, in their first year of reading, did show the same landing position patterns as adults who commonly saccade to fixations in the middle of a word.

Children usually use more frequent and smaller saccades, and suffer from drifts during fixation more predominantly than adults. Saccade latency and accuracy is said to be less precise for preschool children. [8]

Rayner further discusses McConkie et al.'s conclusions that the primary differences between adults and children when reading, is the frequency of refixations that a child makes. Adults were shown to refixate 5 letter words 15% of the time, while a first grade child was shown to refixate 5 letter words 57% of the time. [8]

Pelli et al. report the findings of Gibson, Gibson, Pick, and Osser (1962), who found "dramatic improvement in children between the ages of 4 and 8, in the ability to match letter-like shapes." [10] This appears to indicate the rate at which children develop processing and reading skills and shows that not only are there clear differences between children of different ages, but also, clear differences between children and adults.

Understanding the role of saccades and fixations in reading should dictate the development of future research of children's on screen reading. Children and adults have different eye movement patterns – this suggests that reading is different for the two and thus specific eye movement and reading research must be undertaken in this area. Investigation which expands what is currently known about adults reading for screen and print and how this differs for children is required. Further research which specifically targets children's particular reading and eye movement needs in print and screen should form a high priority in the research in this area.

3. TYPOGRAPHIC CONSIDERATION

3.1 Spacing

Stanley Morison writes in the introduction of *A Psychological Study of Typography*, "Spacing, in fact, is more important than choice of size or design of type." [13] Spacing affects the ability for the eye to traverse successive lines of type with ease. The space between individual letters affects the ease with which letters can be identified and in turn, the ease of recognition of words. The space between words, affects successful transition from fixation to fixation, while, the space between lines, affects the ability of the eye to navigate correctly from the end of one line to the beginning of a new line. For these reasons, we must carefully assess our spacing decisions when approaching a typographic layout, particularly that for children.

Linda Reynolds & Sue Walker [14], state that word and letter spacing has had very little investigation in the research of children's reading. They describe type size, line spacing and line length, as having been examined as important factors, in the design of books for children. This, they claim is evident in the research of Huey (1908), Tinker (1965) and Watts & Nisbet (1974), who make no reference to investigation regarding either letter spacing or word spacing.

In later studies of reading print, Walker [15], states that children in these studies, discussed tight letter, word and line spacing as being seemingly more difficult or confusing to read. This was often due to the children perceiving the size of the type to be smaller and harder to comprehend. From a motivational point of view, taking care not to set type overly tight, may therefore, assist with children's reading and comprehension.

3.1.1 Letter spacing (Tracking & Kerning)

Spiekermann & Ginger [16], discuss the complexity of the letter shapes as requiring care when being set in order to "respect" the space between each letter. They continue, that letters require enough space either side to avoid clashes and, as type becomes smaller, more space is needed either side of a letter. With this in mind, Spiekermann & Ginger also discuss the "unsightly gaps" that occur between certain letter combinations, thus requiring careful consideration by the typographer. Particularly problematic, are 'V', 'W' and 'Y' in both lower and upper case because of their widths and letter shapes and the way other letters interact with these letter shapes.

Crowding is the phenomenon of letters being tracked too closely. This results in meaning being difficult to ascertain from the letter combination. It also causes confusion, through tight spacing and shape adjustments. This may also result in a slowing of the reading rates for experienced readers. A letter surrounded by other letters, when seen in the periphery or para-fovea, is much harder to identify than a single letter. [17] It is thought that "crowding may determine the visual span and thus reading rate." [10]

Gotz [18], suggests that letter spacing on screen, should always have extra spacing to improve legibility. It is suggested that reduced tracking on screen, will accentuate the issue of letters appearing overly narrow. This is caused by a poor contrast in foreground and background colours.

Reynolds & Walker [14], relate that until very recently, some children's reading materials were set fully justified. Because of this, it was common to find a large inconsistency in the horizontal space setting of the type in these books. It is the finding of Reynolds & Walker, that it is not unusual, to see excess space added between words, in reading books for children. However, Reynolds & Walker state, that this is "counter to what is traditionally recognized as good typographic practice." (p. 89) A survey of horizontal space in contemporary reading schemes, undertaken by Cooper-Tomkins in 1994, is reviewed by Reynolds & Walker. This survey revealed that many contemporary children's books suffered from very tight letter and word spacing Reynolds & Walker describe this as being contradictory to the findings of Yule (1988), and Sassoon (1993); while other materials surveyed, were so widely spaced, that children would have difficulty perceiving lines of text. Reynolds & Walker, in their research, conclude that normal and wide letter spacing might prove better for young children's reading material, than tight and very wide letter spacing.

Much of this letter spacing literature is based purely on best practices, the knowledge through experience and the innate expertise of the authors. These hypotheses call for further investigation, particularly for children's on-screen reading.

3.1.2 Word spacing

Word spaces appear to be important for reading English, as they make it clear to the reader where a given word begins and ends.

[19] It is believed by some theorists, that eye movements and saccade programming, are aided and determined, by the length of upcoming words. It is believed that, low-level visual processes, in the parafovea and peripheral, first, analyze the text ahead of the currently fixated word, thus, detecting the length of words ahead by the spaces that segregate these. Secondly, this information is then used to guide the eye to its next Optimal Viewing Position. [19] Research by Epelboim et al. [12] tested these theories by 1) removing the word space from between words, thus joining these words together, 2) by adding an 'x' into the word space, thus removing the word space and 3) by adding an 'x' either side of a word, while preserving the word space. These three actions all brought about a deteriorated reading speed and affected the average length of saccades and fixations, indicating the importance of word space in reading English.

Research by Epelboim et al [12] and Rayner et al [19], suggest that spaces in text also allow for increased ease of reading compared to text with no spaces. Both conclude that this was not due to word length detection alone; but also due to word recognition being made difficult by other words and letters obscuring the shape of the letters and words they now fall next to. It is further believed, that removal of the space between words affects the ability to detect where the present word begins and ends, and therefore, where the next word begins and ends.

Reynolds & Walker [14], have shown that until recently, a large amount of the material for children was set fully justified, resulting in extreme variables of word and letter spacing. Research discussed by Reynolds & Walker, suggests that researchers who have investigated word spacing for children's reading, have encouraged "wider than normal word spacing". (p. 89) According to Reynolds and Walker, Dowding suggested in 1954, that wide word spacing and ample leading was "desirable" for children's books. Burt is also stated as having written in 1960, of "thick space" as a minimum, rather than a maximum for children's material. However, it is stated by Reynolds & Walker that these views are not based on research evidence and that there is little experimental research into horizontal spacing for children learning to read. These suggestions, like those for letter spacing, are based on insight, rather than empirical testing.

3.1.3 Line spacing (Leading)

Continuous set lines of type must be set in such a way, that the type on the line below, is far enough away from the line being read, in order not to distract the eye from its current reading path. In so doing, the next line must be so close that the eye is able to find this line with ease on its return path, after completion of the line above. Should spacing be too wide, the reader becomes aware of both the lines and the space between the lines. Gotz [18], suggests that line spacing should be set to enable the reader to concentrate on the lines of text alone, not on the space between them.

Pages set with little or no space between lines, can make correct line selection on a return sweep difficult and the reader may skip lines. Readers also find it difficult to jump down lines correctly, when lines of type are set too loose. Both Burt [13] and Spiekermann & Ginger [16], suggest that line spacing should be considered carefully for children's reading material because children "are particularly prone to doubling and skipping" lines. [13] Burt also suggests that lines set solid, are not only difficult to read, but would "repel all but the hardened scholar". (p. 14)

Spiekermann & Ginger [16] suggest that line space needs to be bigger than the space between words, in order to avoid the eye traveling from a word on one line, to the next word on the line directly below. A guide, suggested by Spiekermann & Ginger, is that the distance between lines should be approximately 1.5 times the size of the x-height and larger for children. It is also suggested, that the more characters per line, the more line space is required. [18]

Again it is clear that very little empirical research to support these hypotheses exists to date. Screen based research into line spacing is also lacking for both adults and children.

3.2 Line Length

Line length is the measure of lines of continuous text that facilitates the most comfortable reading conditions for the human reader. Spiekermann & Ginger [16] analogize that "long texts need to be read the way a marathon is run. Everything has to be comfortable - once you've found your rhythm, nothing must disturb it again." (p. 129)

Line length is often measured in words or characters per line (*CPL*) or in the physical length of the line, in an appropriate measure such as ems, points, inches or mm, depending upon local metric norms. Line length needs to be considered in order to ensure that a line contains a comfortable number of characters and words for continuous reading. A line must not be so long that it impedes the reader from finding the next line. A line must also be of suffcient length to ensure that a suitable portion of the sentence, phrase or notion is covered in each left to right sweep. [16] Long lines can make it difficult to find the beginning of the next line because of the length the eye must travel on a return sweep. However, it must be considered, that short lines, particularly when paired with a large type size, prove difficult for a trained reader to process a suitable amount of information in a single fixation. Ability for the parafovea and peripheral to analyze upcoming text, will also be diminished by short line lengths. [13]

Burt [13] discusses experiments performed with adults, which showed that 10-point Times Roman set shorter than 20ems, or longer than 33ems, proved to slow reading rates. Burt suggests 55 to 80 characters per line is ideal. This would equate to ten to twelve words per line. This may differ for literary material. It is suggested, that such materials be set in comparatively short line lengths, as opposed to scientific material, where wider line lengths would be suitable. Dyson & Kipping [5] analyze research findings that suggest line lengths should not exceed 70 characters per line. Watts & Nisbet [3], discuss Tinkers' 1959 summaries of reading research for children. Tinker is referenced as having discovered that children in the primary grades can comfortably read lines of 16 to 30 picas (approximately 67 to 126 mm) without this impacting on their reading rate.

Dyson & Kipping [5] discuss findings that different line lengths also have "small, but significant, differences in reading rate" (p. 9) in on-screen reading experiments. The findings of Dyson & Kipping suggest, that lines of 100 characters per line (the longest line length in their experiments) were read the fastest, while comprehension remained constant. It is mentioned, that subjects did refer to the 100 CPL lines as "rather daunting". (p. 10) Dyson & Kipping tested screen reading speeds of lines set at 25, 40, 55, 70, 85, and 100 characters per line. They found that reading comprehension was consistent across all. These findings are in contrast to findings in print, as discussed previously in this thesis.

Dyson & Kipping posit that longer lines being read faster, may be due to reductions in time required in scrolling documents. However, there is also evidence from paged documents, that longer lines in such environments, also result in faster reading rates.

Bernard et al [20] found no significant differences in reading rate or effciency of three different screen-based line length tests. These tests were performed by 20 adults between 19 & 61 years, and 20 children between 9 & 12 years. Bernard et al suggest that the results of these tests and the post test surveys, support findings that shorter line lengths are preferred by readers. Adults tended to prefer the medium line length of approximately 76 CPL, while children chose the short line length of approximately 45 CPL, when questioned.

Dyson & Kipping [5], suggest that due to the disagreement between subjective feedback and empirical findings, consideration of line length decisions for the screen, should entail evaluation of both subjective findings and empirical evidence.

3.3 Margin

Margins are particularly useful in reading consecutive text, as these allow for guiding the eye, while giving visual barriers to the information space and the surrounding information. Margins are important when text abuts illustrations or the edges of books or monitors. Burt [13] suggests that narrow margins produce visual fatigue. He continues, stating that when type is set too close to the edge of a printed page, a young reader will often follow the type right off the page. However, he concludes that for adult readers, large margins prove mostly aesthetic in value.

Bringhurst states that margins have three purposes; “to lock the text block to the page, to frame the text block in a manner that suits its design, to protect the text block, leaving it easy for the reader to see and convenient to handle”. [21]

Burt [13] suggests the two side margins should occupy approximately 1/3 of the page width. This size should then be increased as leading is increased. He continues, for children, margins should be wider still. For the very young child, Burt suggests, lines end with the end of a phrase or sentence, thus leaving ragged margins on the right.

Margin and visual separation between areas of text to be read and image or interface area seem obvious to assist with reduction in distraction to a young on-screen reader. This area of investigation is specific to on screen reading and would greatly benefit future investigation.

4. SCREEN-SPECIFIC CONSIDERATIONS

While certain principles of design and typography, developed over many centuries of visual communication, are quite clearly transferable from print to screen, many new principles and investigations must be undertaken to understand fully the nature of visual communication in this screen-based medium. Designers, typographers and researchers must acknowledge that issues surrounding readability and legibility, currently require further investigation.

The screen is clearly a very different medium from that of the printed form. Type for the screen is not limited by economic considerations of print; thus, how a designer approaches this medium should be different. Considerations of space, size and colour are therefore, not as economically constrained on screen, as they might be in print.

Type on screen is presented via rectangular pixels; thus, size and shape of typefaces chosen, are of consideration. A typeface and its letterforms must be robust, clear and recognizable, with considered use of letter spacing in order to be readable and legible in this less than satisfactory presentation medium.

Colour on screen is different from colour in print because it is an additive colour system, rather than the reflective colour system of visual colour mixing. Colour on screen is brighter than colour in print; thus, contrast is important to ease the discrimination of colours. Colour is also less standardized across multiple monitors, than colour across multiple prints from the same printing press. [18]

Reynolds & Walker [14] have shown that complexity on screen has a negative effect on children’s preferences and can scare children away from the material. Teachers in their study discuss the less effective search techniques of children and the need for clear presentation of text and effective visual cues for reading. For this reason, careful consideration of layout, navigation and division of text and image will benefit young users. Line length and margin is an aesthetic consideration on screen, that will aid in avoiding this visual complexity. Children’s preferences seem to lean toward a somewhat shorter line length with generous use of margins and padding around text blocks.

5. CONCLUSIONS

It seems clear from the literature, reading relies on effective use of type to facilitate effective eye movements. The eye movements required for effective on screen reading for children differ from those required for adults. Dyson [2] states, that after 20 years of empirical research for screen based reading the body of knowledge is still without rigour. She suggests that this is in large part due to the technological advancements and the requirement of studies which replicate, rather than extend results. With this the case, it is clear that specific knowledge of children’s screen based reading needs are not currently understood. This writer believes, more research into the effects of typographical space on eye movements during children’s on-screen reading is required.

Dyson suggests that a possible reason for the lack of specific investigation into screen based reading could be due to the diversion of research attention towards the human factors relating to navigation. The unique navigational and reading methods associated with screen based research and reading have produced a research area which is unparalleled in print. [2] Even with this reasoning, it seems clear that as we draw nearer to sound answers to the fundamental concerns relating to screen based navigation it is time to redirect our research towards the unique reading needs of the screen and particularly those of children.

It also seems reasonable that researchers with diverse areas of disciplinary expertise align in their investigations of typographic legibility. Collaborative investigation from the fields of graphic design, typography, education, psychology and HCI will result in testing methods and results with greater validity and rigor than has been seen to date. As is suggested by Dyson [2] the aligning of experts with a scientific knowledge of the testing procedures and eye movements with the practical knowledge of typographic presentation will enhance testing in the future. This writer calls for the inclusion of experts within the fields of education to offer practical reading and usage insights, while, experts within the

filed of HCI may reliably be expected to bring forward a view to effective interaction and knowledge of specific screen based reading considerations.

6. ACKNOWLEDGMENTS

The writer thanks and acknowledges the work of Emmanuel Turner, University of Waikato, thesis supervisor during the masters research [1] from which this paper stems.

7. REFERENCES

[1] N. Vanderschantz, "Consideration of On-screen Typography can Assist with Children's Comprehension: the influence of spacing in reading English." Unpublished masters thesis, Wanganui School of Design, New Zealand. Nov. 2007.

[2] M.C. Dyson, "How physical text layout affects reading from screen.," Behaviour & Information Technology, vol. 23, Nov. 2004, pp. 377-393.

[3] L. Watts and J. Nisbet, Legibility in children's books : a review of research, Windsor : NFER, 1974.

[4] A. Dillon, "Reading from paper versus screens. A critical review of the empirical literature.," Ergonomics, vol. 35, 1992, pp. 1297-1326.

[5] M. Dyson and G. Kipping, "Exploring the Effect of Layout on Reading from Screen," Proceedings of the 7th International Conference on Electronic Publishing, Held Jointly with the 4th International Conference on Raster Imaging and Digital Typography: Electronic Publishing, Artistic Imaging, and Digital Typography, 1998, pp. 294 - 304 ; http://scholar.google.com.

[6] A. Creed, I. Dennis, and S. Newstead, "Proof-reading on VDUs," Behaviour & Information Technology, vol. 6, 1987, pp. 3-13.

[7] E.B. Huey, The Psychology and Pedagogy of Reading with a Review of the History of Reading and Writing and of Methods, Texts, and Hygiene in Reading, The Macmillan company, 1908.

[8] K. Rayner, "Eye Movements in Reading and Information Processing: 20 Years of Research," Psychological Bulletin, vol. 124, 1998, pp. 372-422.

[9] E. Matin, "Saccadic suppression: A review and an analysis," Psychological Bulletin, vol. 81, 1974, pp. 899-917.

[10] D. Pelli et al., "Feature detection and letter identification," Vision Research, vol. In Press, Corrected Proof, 2006; Science Direct.

[11] F. Vitu et al., "Fixation location effects on fixation durations during reading: an inverted optimal viewing position effect," Vision Research, vol. 41, 2001, p. 3513.

[12] J. Epelboim et al., "Fillers and spaces in text: The importance of word recognition during reading," Vision Research, vol. 37, 1997, p. 2899.

[13] C. Burt, A Psychological Study of Typography, London: Cambridge University Press, 1959.

[14] L. Reynolds and S. Walker, "'You can't see what the words say': word spacing and letter spacing in children's reading books," Journal of Research in Reading, vol. 27, 2004, pp. 87-98.

[15] S. Walker, The songs the letters sing: typography and children's reading, Reading : National Centre for Language and Literacy, 2005.

[16] E. Spiekermann and E. Ginger, Stop Stealing Sheep & find out how type works, Berkeley, California: Adobe Press, 2003.

[17] R. Hess, S. Dakin, and N. Kapoor, "The foveal 'crowding' effect: physics or physiology?" Vision Research, vol. 40, 2000, p. 365.

[18] V. Gotz, Color & Type for the screen, Switzerland: RotoVision SA, 1998.

[19] K. Rayner, M. Fischer, and A. Pollatsek, "Unspaced text interferes with both word identification and eye movement control," Vision Research, vol. 38, 1998, p. 1129.

[20] M. Bernard, M. Fernandez, and S. Hull, "Usability News - 4.2 2002 -- The Effects of Line Length on Children and Adults' Online Reading Performance," 2002; http://psychology.wichita.edu/surl/usabilitynews/42/text_length.htm.

[21] R. Bringhurst, The Elements of Typographic Style, USA: Hartley & Marks, 2004.