Notes on legibility

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Font size

- When text is less than 6 points, accuracy declines. [1]
- No significant difference in reading performance when comparing small differences, such as 10-point to 12-point. However, differences may be found in bigger differences. [1]
- Almost no effect with children. [2]
- At 1024x768, you might expect to see a dropoff in reading performance when the type goes below 9.75-point. [2]
- A significant difference in readability might be evident when comparing 2.0 mm and 3.0 mm x-height fonts, but probably not so much when comparing 2.0 mm and 2.5 mm. [2]

Font family

- Georgia and Verdana were specifically designed for the screen. Times New Roman and Arial were not. [4]
- Participants slightly preferred Georgia over Verdana and were slightly faster and more accurate when reading with Georgia. [4]
- Participants rather strongly preferred regular Verdana over Verdana italic, although performance was about the same. [4]
- Effective reading speed was very slightly higher with Times New Roman than Georgia, but Georgia was preferred and more accurate. [4]
- Arial preferred to Times. [1]
- 12-point bitmap Arial was most preferred. 10-point anti-aliased Times was least preferred. [1]
- Small changes in the font size, family, or display method (bitmap vs. anti-alias) do not significantly affect reading performance, although they may affect preference. [1]

Anti-aliasing

- No significant difference among bitmap, Microsoft anti-aliased, and Adobe anti-aliased, although people generally prefer anti-aliased to bitmap. [4]
- Slower, especially with serif fonts, or with smaller fonts. [1]

Physical dimensions

- With Huey's enhanced format (1908), you indent every other line by 3 spaces in order to facilitate return sweeps. No difference in reading rate, but 13 out of 18 subjects in a 1991 study preferred Huey's format to standard text. [6] See also Muter and Maurutto (1991).
- Left-hand margin should be justified. [6] See also Bouma 1980.
- Narrow characters lead to more fixations per line, but fewer fixations overall because your eyes can take in more words per fixation. [6]
- Assuming a constant line length and character height, 35 wide characters per line is less efficient to read than 70 narrow characters per line. [6]
- Some have suggested that a smaller type size might yield more accurate reading because the text is closer to the center of your vision where your eyes are most accurate. [6]
- Regarding physical length of the line of text, small differences make almost no difference, but bigger differences may have a difference. [6]
- If the type size is kept constant, longer lines are read faster than shorter ones. It was suggested that this may be due to glare, distraction from margins, or less scrolling time. [6]

- In a study that varied characters per line and margin size, the best performance was with maximal long lines and no margins. [6]
- People *perceive* multiple columns as easier to read. Actually, two-columns are faster than one column, but one column is more accurate. [6]
- Double spacing can be faster to read, depending on the experiment design. [6]
- People prefer medium length lines, saying they are more organized and easier to read. However, longer length lines are actually faster to read. [6]
- One study found that "well-designed" (clearly organized) study materials were more effective for teaching than poorly designed materials. However, a different study found no performance difference between "well-structured and ill-structured" documents, although people preferred the well-structured documents. [6]

Dynamic text (e.g. scrolling, rolling, flashing, etc.)

- Presentation method had a greater effect than screen size. [8]
- Reading speed was fastest using the RSVP method of displaying one word at a time, as compared to teletype, leading (slide right to left), vertical scrolling, and other methods. [8]
- Most suitable methods for various devices: [8]
  - PDA, mobile phone – vertical scrolling
  - Communicator – leading or teletype
- People read faster with vertical scrolling than with a whole page of text, although this is mediated by the fact that the machine set the pace, which was specified by the user during practice. This is not normal vertical scrolling as we know it. [8]

Children

- Very insensitive to changes in typography. Children's reading strategies, motivation, and reading level are the dominant factors that affect readability. Typical readability experiments have much less value when researching reading by children. [2]
- Preferences:[2]
  - 14-point better than 12-point
  - Arial or Comic better than Times and Courier
  - sans serif better than serif
  - Comis most attractive, most preferred, probably due to the informal and playful appearance.
- Recommendations: [2]
  - sans serif
  - medium to large x-height
  - modest amount of letter spacing and character weight

Paper vs. Screen

- Paper may be easier to read, but this is strongly affected by the quality of the screen and the design of the experiment. This is based partly on the assumption that computer screens hold more information than paper. Note that this paper was a review paper published in 1987 about work done prior to 1987. [9]
- If enough variables are constrained, then there is no difference. If you compare a photograph of a screen, and the real screen, there is no difference. The main distinction is the resolution of the screen. A photo of a screen will have roughly the same resolution. However, as screen resolution improves, we expect to see even less of a difference. [12]
- Eye fatigue is negatively correlated with display resolution. high resolution → easy on eyes.[14]
- Single variable explanations are insufficient to caputure the range of issues involved in reading from screens. [5]

Sub-pixel rendering of fonts on LCD displayes

- ClearType takes advantage of the fact that each pixel is actually 3 stripes for red, green, and blue. Instead of drawing diagonals using blocks of whole pixels, it varies the color of adjacent pixels to get a group of red-green-blue pixels in any order. This effectively gives you higher resolution for text, and potentially any vector graphics. They use some fancy techniques to make sure the color doesn't come out looking strange. [3]
- Jakob Nielson says ClearType increases reading speed by 10-15% but doesn't specify a source. He also argues that companies can save $2000 per employee by enabling ClearType. [11]
- Some people claim that Apple did this on the Apple II. This seems doubtful given that sub-pixel rendering is targeted at LCD monitors because of the way the RGB components are arranged. Some
- There's a slightly different, fee-free, patent-free implementation called SubLCD. It also takes advantage of the difference in luminosity of the red, green, and blue subpixels. [13]
- According to some web sites (e.g. http://www.u-publish.com/ebn2.htm), CoolType and ClearType are the same thing and sub-pixel rendering has been around since the Apple II.
- Patent status is unclear. ClearType is patented (#6,307,566), but that has not deterred Adobe or the creators of SubLCD.
- Microsoft's web site as well as [7] say ClearType can improve legibility a little bit on CRT monitors as well, mainly because it incorporates aspects of anti-aliasing.
- Works best on black and white and only in landscape orientation [7].

Vista Fonts

- Looking around at Microsoft's web site, and elsewhere, I don't see any evidence that these fonts represent any new research, other than a fresh effort at making attractive fonts to enable more comfortable on-screen reading.
- Main contributions: Calibri, Cambria, Candara, Consolas, Constantia, Corbel
- They also created Meiryo {MAY-ree-oh}, a Japanese font, and Segoe UI, a UI font optimized for viewing in the 8 to 10 point range. Meiryo is an alternative to MS Gothic. Segoe is an alternative to Tahoma.
- A sample of all of these fonts is included later in this document.

Screen resolution

- Screen resolution may be the single biggest factor influencing any differences between reading on screen and reading print. [12]

Experimental details

- Choice of reading passages:
  - Sections of Microsoft Encarta were used in [1].
  - Whootie Owl's Fairytales for [2].
  - Nelson-Denny Reading Test gives 2 forms of similar difficulty and structure. May be available from the Riverside Publishing Company. [4]
  - News stories were used for [8].
- One way to account for inaccurate reading is to take

  `effective_reading_speed = comprehension_questions_right / time` [4]
- Need to control for differences in reading using Snellen near acuity test. [1]
- Control for glare on screen by placing lights over-head and to the side. [1]
- Likert scale used for preferences in [1] [2]
- Account for reading level by using passages with the same Flesch-Kincaid Grade Level Assessment score. [1]
- For measuring accuracy, [1] used a proofreading task where similar rhyming words were switched such that the new word would be totally inappropriate for the context (e.g. "take" → "fake"). This is better than checking spelling because it requires full comprehension.
- For children, it is more important to measure subjective perceptions than to do adult-style readability experiments. [2]
- One study mentioned in [6] had the participants scan the text for shape words (e.g. "triangle", "circle", etc.) and then click a corresponding shape icon at the bottom of the screen. [6]

Mediating factors

- Type size, line length, line spacing, and font should be taken *together* when making decisions. [4]
- x-height can be very different, even when the point size is the same. For example, at 12 points, the x-heights of Times and Arial are 2.0 and 2.5 mm, respectively. [1]
- Typographical variables are extremely interrelated. This cannot be ignored. For example, if you change the font size, then either words-per-line or inches-per-line must change. Either way, you would expect a secondary effect. Thus, the only way to study this is to compare different combinations of dimensions. Miles Tinker, one of the pioneers of readability research, did some such studies, but that is rare. [6]
- You can't generalize print standards to the screen. [6] See also Grabinger and Amedeo 1988.

Selected Terminology

- extenders – part of the letterform that rises above the x-height, or sinks below the baseline. [2]
- serifs – extra corners added to fonts like Times New Roman in order to help the reader distinguish letters and words. [2]
- fixation – a tiny pause made by your eye as it scans a line of text. [6]
- saccade – quick movement of the eyes together (e.g. return sweep) [6]
- x-height – the height of a lowercase x in a particular typeface, as measured in either point or millimeters.

Sans Serif	
Calibri:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Candara:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Corbel:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Arial:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Verdana:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Serif	
Cambria:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Constantia:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Georgia:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Times N. R.:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Sans Serif	
Consolas:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Courier:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Just for the Windows UI	
Segoe UI:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Tahoma:	I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone. --Bjarne Stroustrup
Japanese	
Meiryo (new)	以前からパソコンが電話ぐらい簡単になるのを望んでいました。やっと、その時が来ました。もう電話の使い方も分からなくなってきたぐらいです。
Gothic (old)	以前からパソコンが電話ぐらい簡単になるのを望んでいました。やっと、その時が来ました。もう電話の使い方も分からなくなってきたぐらいです。

References

[1] Bernard, M., Chaparro, B.S., Mills, M.M., Halcomb, C.G. Comparing the effects of text size and format on the readibility of computer-displayed Times New Roman and Arial text. *International Journal of Human-Computer Studies* Volume 59, Issue 6, December 2003, Pages 823-835.

[2] Bernard, M., Chaparro, B., Mills, M., Halcomb, C. Examining chilren's reading performance and preference for different computer-displayed text. *Behaviour & Information Technology*, 2002, Vol. 21, No. 2, 87-96.

[3] Betrisey, C., Blinn, J.F., Dresevic, B., Hill, B., Hitchcock, G., Keely, B., Mitchell, D.P., Platt, J.C., Whitted, T.. Displaced Filtering for Patterned Displays, *Proc. Society for Information Display Symposium*, pp. 296-299, (2000).

[4] Boyarski, D., Neuwirth, C., Forzlizzi, J., and Regli, S. H. A Study of Fonts Designed For Screen Display. In *Proc. CHI 2002*, ACM Press (2002), 87-94.

[5] Dillon, A. Reading from paper versus screens: a critical review of the empirical literature. *Ergonomics*, 35(10), 1297-1326.

[6] Dyson, M.C. How physical text layout affects reading from screen. *Behaviour & Information Technology*, Volume 23, Number 6, November-December 2004. Taylor & Francis (2004), 377-393.

[7] Gibson Research Corporation. http://www.grc.com/ctwhat.htm, accessed 3/1/2007.

[8] Laarni, J. Searching for optimal methods of presenting dynamic text on different types of screens. *Proc. 2nd Nordic Conference on Human-Computer Interaction*. ACM Press (2002), 219-222.

[9] Larson, K. 2004. The Science of Word Recognition: Or How I Learned to Stop Worrying and Love the Bouma. July. Microsoft Typography site. Accessed 3/1/2007.

[10] Mills, C.B., Weldon, L.J.. Reading text from computer screens. *ACM Computing Surveys* Volume 19, Issue 4, December 1987. ACM Press (1987), 329-357.

[11] Nielson, J. Avoiding Commodity Status. http://www.useit.com/alertbox/20020203.html, accessed 3/1/2007.

[12] Shneiderman, B., Plaisant, C. *Designing the User Interface: Strategies for Effective Human-Computer Interaction (4th Edition)*. Addison Wesley (2004).

[13] SubLCD. http://www.oyhus.no/SubLCD.html

[14] Ziefle, M. Effects of display resolution on visual performance. *Human Factors*. Volume 40, number 4. Human Factors and Ergonomics Society, Santa Monica, CA (1998), 554-568.