

A Comparison of Link Readability Techniques

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Abstract

Hyperlinks are an important means for navigating the Web, and are a major influence in the usability of web pages and web content. However, the visualization representation of links has not been fully explored.

This paper reports on a survey taken that studied how personal preferences affect the way people would like to see links visually represented on a web page. Web pages with various visual representations of links were presented to average web users and were rated and commented on with regards to how easy the pages were to read and what the users' personal opinions about them were. Opinions on link consistencies were also taken.

The findings show that readability of text should be carefully considered for the design of future web browsers. I hope to increase awareness for this critical feature of the web so that as new web standards are being determined, such as XLink, the visual aspect will also be discussed and determined so that all browsers can also follow the potential visualization standard in the future.

1.0 Introduction

Links are one of the most important means for navigation in the World Wide Web. Studies show that users view links as the most important way to find new web pages. [8] However, the visualization of links has not been fully explored. [6] The web is about to become a much more robust and more easily navigable arena once new technologies such as XML and XLink are implemented by browsers. Links can become multi-directional and could have multiple destinations from one hyperlink. These new functionalities need to be made usable and easily understandable by web browser users. Before a user clicks a hyperlink, they need to know what is going to happen and where they are going to end up so that they don't feel 'lost in hyperspace'. The new link technology needs to allow users to still perform typical actions, such as purchasing items and finding specific content, likely by searching. It also has to allow for high readability of content-rich web pages. Once browsers start to implement the most preferred linking and link visualization techniques, the web will likely be even more user friendly and overall user satisfaction should increase.

The current implementation of links is to make them blue and underlined. This results in reduced readability of web pages, as documented by several research projects that explored usability issues with regards to how to visualize links.[6] The findings of these projects are discussed in more detail within the next section. The implementation of the link visualization that currently exists allows web page designers to change the colors and looks of links. Some web pages remove underlining and coloring of links by using images or other techniques so users really have no idea what is a link and what isn't. A user also may not know where he/she has been when the link doesn't change somehow to let him/her know it has already followed it once. These are common practices by web designers, resulting in users getting confused with this inconsistency across web pages. Users

need a consistent visualization of a link even if the colors used vary. Having a default color that the majority of web page designers can tolerate would be beneficial for the average web user.

This research is meant to help determine which visualization technique is most preferred by average web users, taking into consideration currently emerging technologies. The goal of this research is to establish which options and techniques are most preferred by average users, in order to help determine the most effective link visualization method for common use on the web. Some researchers and web users suggest that highlighting is a better visualization technique for links than blue underlining because this method is less obvious and less intrusive when users are reading content on web pages. Web designers will still figure out ways to change the colors of the highlighting or use images instead of the normal linking techniques, i.e. if the chosen background color for the page is the same color as the default color of highlighted text (link), then a custom color for the highlighting will need to be used. Although the results of this research will not be taken as a governing set of standards for the web designing industry, it is hoped that web user preferences regarding link visualization methods can be established and that web designers can develop a semblance of uniformity by following the standards put forth by the World Wide Web Consortium (W3C) and using these documented inclinations.

2.0 Background

The W3C Organization has recently (2001) recommended a set of linking standards to be used with the Extensible Markup Language (XML). This new standard changes Web hypertext functionality at the most fundamental level – in the Web's document specification standards.[2] XLink supports simple links like those on the Web today as well as extended links, which can be bi-directional, n-ary, and stored in a link database.[3] An XLink consists of an arbitrary number of resources and arcs, connecting a source text or object with one or many destination resources by using arcs.[6] An arc directs the connection between two resources, so that two resources can link to each other using two arcs. The arc definitions are stored in a linkbase. A linkbase is a server or database dedicated to the storage of links, so that anyone could add links to the read-only material on the Web.[6] With this new limitless way to add links to a page and also new technologies allowing the addition of annotations to web pages, the density of links per web page could be significantly increased.[6] As technologies such as adding markers for annotations compete for a reader's attention, discernability and readability of links and linked text becomes increasingly important.[6] Studies show less than 1% of links are embedded links, possibly because authors believe it causes readability problems.[6] Unlike current uni-directional, embedded links, XLinks could easily overlap another link if multiple authors store links in linkbases slightly differently.[6] If authors start giving links classifications or types, users can learn what it means, helping to give the user a better idea of the link target and

what will happen when they click it.[6] A XLink browser needs to be able to find linkbases and add them to a user's personal list, but no means has been established to do so yet.[9] Providing information on the Web will become more link-based in the future, due to third parties being able to create linkbases and charge for their use.[10] The ultimate success of XML will take time because even once browsers support it, people will still use old browsers.[10] W3C proposed XLink as standard for XML, defining syntax elaborately but leaving visualization and interaction with extended links undefined.[9]

2.1 Colors and Wavelengths

Numerous studies have shown that about 70% of people say that their favorite color is blue.[4] Unfortunately, elderly people have trouble perceiving blue because it is hard to bring in to focus due to the chromatic aberration of the eye.[9] The eye gets progressively less sensitive to the color blue compared to other colors over time, and so the ability to focus on blue decreases with age.[9, 7] Blue has a short wavelength, making a sharp blue image impossible to obtain because it can never be brought into focus.[7] Short wavelengths have lower resolution because they are blurred by the ocular media, so readability of text in short wave light will be decreased.[5] Red is at the opposite end of the visible spectrum, being the longest wavelength.[5] The retina only has a very small number of cones that react to short wavelengths, leading to a variety of guidelines stating that blue is a bad color for small objects like text, but is good as a background color.[7] Some studies report that warm colors (red, yellow) imply activity while cool colors (blue, green) imply background.[7] Various studies show opposite results, sometimes saying blue is a good background and sometimes saying white is a good background.[7] Other factors to take into consideration when deciding on colors for web page text or backgrounds include facts like eyes are most sensitive to green in low light conditions (why night vision is in green) and that people also tend to like to see colors they have had good experiences with and colors that appear in nature.[4] When extremely different frequency colors are mixed they quickly fatigue the eyes because the wavelengths have different focal lengths.[5]

2.2 Previous research on readability

Some historical linking techniques have been to put a link symbol in between lines of text, like an arrow, or to draw a box around the text, or to use a variety of text colors and styles.[9] These techniques don't provide end points to the links, interfere with page formatting, or waste screen space, while also are confusing.[1] Using text formatting techniques like bold and underline limits the options for emphasizing text that is not a link, and also adds emphasis to a word or phrase that isn't intended.[9] One study that had participants view web pages with different text and background colors reported that the color combinations that had the fastest time were green text on a yellow background and the slowest times were red text on a green background.[5] This study also noted that black text on grey was faster than black on white backgrounds.[5] It seemed light on dark was slower than dark on light backgrounds in general.[5] Many books recommend opposing techniques such as yellow on white (low contrast) while others recommend high contrast, like black on white.[5]

2.3 Highlighting visualization technique

Blue underlining comes from old browser prototypes – it was easy to implement, blue was the closest color to black in a 16 color display, and for monochrome displays, underlining was added.[6] Underlining is known to reduce readability of text significantly, as it interferes with letters that drop below the line.[6] Italic and bold should be used to highlight or emphasize important text.[6] Changing the background color (highlighting) has the advantage that text style can be chosen freely, no extra space is needed and overlapping links become possible.[6] An alternative called links-on-demand draws boxes around links after the user presses a key meaning he wants to see the links, keeping the text pristine the rest of the time, but requires the users to use more keystrokes to find what they want, if they are looking for more information.[6] One study showed that when users were timed while performing web-like tasks on plain text, blue underlined text, and light blue highlighted text, that plain text was the fastest, with the highlighted text being second best[6]. This study also showed that with blue underline, users were easily led to wrong answers to questions more than 50% of the time.[6] But when the users rated how well they liked to view and read the three different texts, plain text was again the highest, but blue underline was the same as highlighted text.[6] Overall most participants preferred highlighted text for being less contrasting to regular text and good for reading.[6] Similarity to highlighting on paper was noted as an advantage.[6] A few said it emphasized the link too much and was distracting, and could be problematic with various colorful pages.[6] These studies showed that design is vital since small changes in appearance can cause measurable and subjective differences in usability.[6] Highlighting can be more flexible, applicable to graphics, and ready for future requirements like XLink.[6]

3.0 Survey

This survey was performed in order to help determine if highlighting would be a good visualization technique to implement the new XLink specifications. Colors were chosen for test web pages based on typical preferences and current linking colors. The highlight colors were chosen similarly, with a few brighter colors to purposely make some pages more difficult to read than others. The control page was the last test article (#8), which used the current browser technique of making links blue and underlined. A bias towards this technique was expected and a faster read time was expected for users who use the Web a great deal. The softer highlights were expected to be the next fastest read times and next highest in user preference. The articles were all taken from various web sites, but all ads, navigation bars, colors and links were removed. New links were added to each page randomly. The articles were chosen of similar length to try to compare average read times. The interest level of the participant was important and so the same articles were not reused, lest the reader get bored and start skimming the articles.

3.1 Survey description, metrics

The survey was sent by email to a variety of internet users (10) known by the researcher. Users were not paid. They were given instructions to visit a website which contained directions and listed eight web pages of test articles. The users were of varying ages, from 24yrs-

Article Title/Subject	Color/Technique used	Number of lines	Number of words	Number of links
1. Homeland Insecurity	Bright blue highlighting (#6666FF)	89	1152	12
2. Black Holes	Light blue highlighting (#DDDDFF)	62	819	11
3. Adventure Racing	Light grey highlighting (#DDDDDD)	82	1221	13
4. CNN 2003 Summary	Light red highlighting (#FFDDDD)	81	1035	12
5. College Bound	Bright red highlighting (#FF6666)	69	923	11
6. AT&T Networking	Light blue highlight (#DDDDFA), bright blue text (#3333FF), underlined	79	1087	11
7. The Toy Book	Light red highlight (#FFDDDD), bright red text (#FF6666), underlined	96	1243	14
8. Hemingway Goes Fishing	Bright blue links, underlined (normal)	76	917	11

Figure 1 – Test article descriptions

35yrs, and used the internet anywhere from 3hrs to 55hrs per week (average 18.1hrs). The users were instructed that they should read the eight (8) test articles as if interested in the content, but to focus on readability of the text in regards to visual representation. The directions also stated that the users were to time themselves reading each article and note the value on the survey. After answering the rest of the survey questions, the survey document was emailed back to the researcher. All of the users used a Windows platform to view the web pages and reported that regardless of which browser (Internet Explorer (5), Mozilla/Netscape (5)) was used, they saw a white background.

The test articles were of varying lengths, from 62 lines (819 words) to 96 lines (1243 words) long. Each article had from 11 to 14 links (average 11.8). Figure 1 shows the test articles in more detail.

4.0 Results of Survey

4.1 Read Times

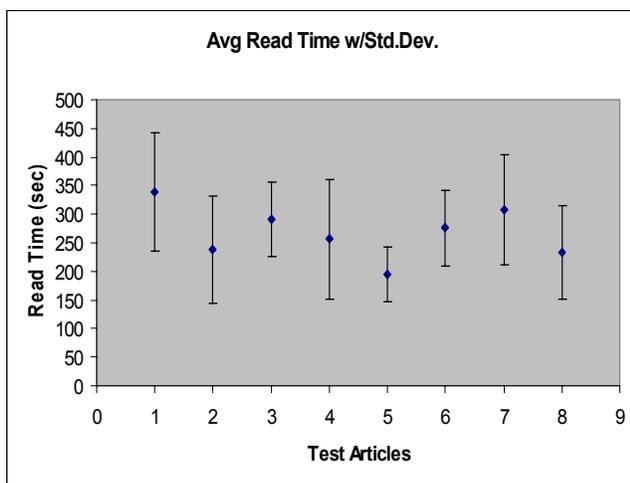


Figure 2 – Average read times with standard deviations for test articles.

Users were asked to record the time it took them to read each test article, rounded to the nearest second. Figure 2 shows the average times for each article and the standard deviations. Article 5 had the fastest read times, but was the third longest in number of words. This article used a bright red linking technique and was about college bound people. This article received some of the lowest rankings from the users, so it is likely the users skimmed more of the article than actually read it, since they said it was difficult to read. The second fastest read time was for article 8, the ‘normal’ links. The third fastest article read was the first, which was light blue highlighting for links, but it was also the shortest article in total words. The only two other articles that were more than one position away in read times than from their rank in terms of length were article 1 and article 7. Article 1 was the bright blue links and it was the 6th longest in terms of words, but was read the slowest. This confirms that bad highlights have a severe adverse affect on readability, but is only one example. Article 7 used light red highlights over red text with underlining and was the sixth fastest read time, but was the longest in length. This indicates that highlighting actually improved read times compared to just changing link color and underlining. However, article 6 - which used the same technique only in blue - was read 5th and was also 5th longest. Consequently, these results don’t seem to provide any solid evidence for any of the techniques being worse than others.

4.2 Subjective Rankings

Figure 3 shows user rankings of each article on a scale of 1-5 with one being the least readable and 5 being the most readable, with standard deviations. The article that used ‘normal’ links received the highest ranks, while the article that used the bright blue links received the lowest. The three articles that used highlighting with no underlining or text colors received similar grades, all between 3 and 4. The blue highlights with blue text and underlining received higher grades than the same technique used with red, but the standard deviations showed significant overlap.

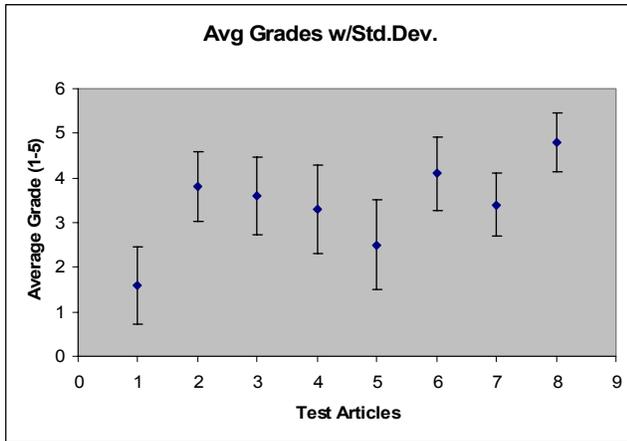


Figure 3 – Average readability grades on 1-5 scale for test articles.

Figure 4 shows rankings of articles put in order from best (most readable) article, to worst (least readable) with standard deviations. Users were asked why they ranked their top ranked page as the easiest to read. Answers varied from describing that the links were obvious but not intrusive to users were just used to seeing links as blue and underlined. The users who did not rank the blue underlined article as their top rank, said that they chose a highlighted option with colored text because it showed up well and was underlined and was also easy to read. When asked if they preferred the highlighting with or without the underlining, 9 of 10 responded that links should be underlined. The other respondent said that just the highlighting alone made the link easy to see and didn't distract from the context.

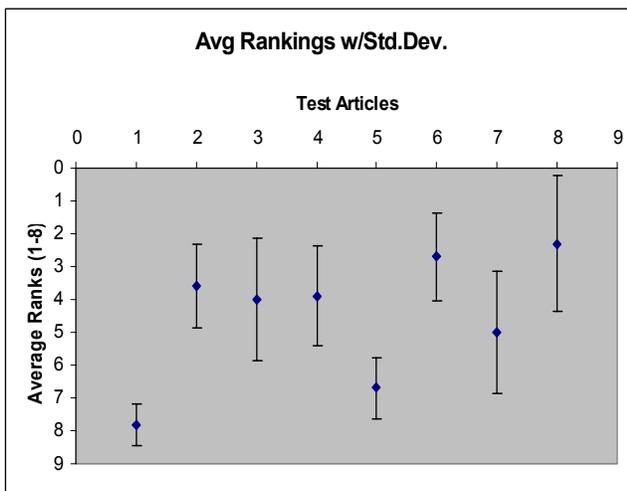


Figure 4 – Average readability rankings for test articles.

The first article with bright blue highlights was consistently ranked as the worst article by the respondents, with the bright red highlights almost always coming in second worst. The 'normal' links article received the highest average rank, but also had the highest standard deviation. The rest of the highlighted articles received the mix of the middle ranks, with the red highlight with red text and underlining coming in low, but with a high standard deviation.

4.3 Additional Survey Data

Almost all users answered that links were distracting on test numbers one and/or five (7 out of 10). Most commented that the dark highlight colors (bright deep blue and bright deep red) were extra noticeable and distracting to the eyes while trying to read. These same test articles were labeled difficult to read because of the lack of contrast between the black text and the deep, bright highlight colors. Multiple users also commented that the deep blue (test one) was a high contrast from the white background, making it difficult on the eyes to read the text smoothly. Users said they had to stop and focus on the highlighted word in tests 1, 5 and 7. One user stated, "The links drew the eyes away from the text". Two users said test 7 was difficult to read because the highlight color was not contrasted enough with the color of the highlighted text (medium red).

Question seven asked if the users had any issues finding links on the test pages. Most respondents said that it was trivial to find links on each page, but most mentioned that it was easiest on pages where the links were underlined (with or without highlighting). Two people said page three (grey highlight) was the least easiest to find links on. Multiple people said that the brighter links were easier to find, but made the page harder to read.

Users were asked if they set their browser preferences to choose link colors or background colors, but most responded that they stick with the default blue underlines or whatever the web designer sets up for them. One participant did respond that they like to set colors so it is not a distracting factor when visiting various web sites. Users were split as to whether or not they would prefer to choose the background and text colors of every page they visit - three said yes, three said no, and four said sometimes or not sure. Some specified that they like to see what designs web sites come up with and enjoy variety. Others said they don't like such a wide variety and prefer to have things look the way they customize them. One user also said that text centered pages should be black on white, like a regular printed book would be, but that advertisements and other things should be a variety of colors. Most of the users (6 of 10) said they would choose a background that is light colored (grey, white, light green) and a dark text (black, dark blue, dark green). One user said that black text on white background does make their eyes tired after a while.

Question twelve asked users if they prefer that links change colors once they have visited them. One user replied that they don't use that feature very often, but thinks the traditional purple color is fine. The other nine respondents said that there should be some visual indication that you have visited the link. Additionally, the participants stated that the color of the text should change, preferably to a darker shade than it was before, even if highlighting was the current linking technology. Most said that this color should be similar to the traditional purple, though some responded saying it could be red or black.

Finally, users were asked if they thought they would have a difficult time adapting to a new linking technology and a new visualization of links. Eight users said they don't mind change as long as there is some cue, such as the mouse, to tell them where the links are. Another user said it might take some time to adjust, but if the new look is consistent, it would be easy. One user worried that highlights might clutter pages too much, but if it was a simpler color change, it would just take some time to get used to.

Users asked to rank on a scale of 0-10 how much they rely on the mouse pointer to give them information about a link and where it will take them (0 being not at all, 10 being almost every link clicked). The average answer was 5.9, with frequent comments about checking to see where the link will take them before clicking it. Two users said 10, while three users said only 2.

One user had extensive extra comments at the end of the survey, saying that the three articles using underlining were the easiest to read, but that they remembered more about the article ranked the lowest in readability. The brightness of highlighting forced the reader to stop and think about what was just read so that the context became very evident when trying to decipher the highlighted word. The easy to read text didn't leave any lasting impressions upon the reader and so the user didn't remember as much about those articles that were ranked highly as the ones ranked lower. The user also pointed out that although it was assumed that blue could be read more easily than red, the results indicated that the two articles that used shades of red were in fact easier to read. The red articles ranked higher than even the grey highlighted article, which was a surprise to the reader.

5.0 Discussion

The read time results, rankings and grades seemed to indicate contradicting things about the articles. The article with the fastest read time was not the shortest article, but was one of the lowest graded and ranked articles. Therefore it is likely that either the users skimmed more of the article than actually read it, or else the best and most readable way to display links is a stark bright red that is aesthetically unpleasing. The only other article that had a read time better than it's ranking by length was article 6, which used light red highlights with red text and underlining. This could indicate that links using multiple visual identifiers may not impair reading speeds, and could possibly improve them. It is possible that the participants were more interested in this article than the others and subsequently biased, but data to support this theory is unavailable. These two articles received ranks 6 and 7 on average, so even though they were read quickly, they were not ranked highly. They received average grades of 2.5 (article 5) and 3.4 (article 7), which indicates that the respondents probably skimmed both of these articles, resulting in their faster read times. This conclusion seems to indicate that readability needs to be measured by something other than how long it takes to read a web page.

The two articles with bright links (#1 and #5) were read the slowest and fastest. This could be explained by added time for the first page where links were difficult to read, and subsequent skimming of the next article with similar links instead of reading closely. Unfortunately, these results are inconclusive for proving the benefit or hindrance to read times of the bright links. These articles received the two lowest grades and rankings, so it is shown that the readers felt that the pages with the bright highlighted links were not pleasing to the eye.

Articles 2, 3, and 4 were the articles that used highlighting without any other link visualizations. These articles had read times of 3rd, 7th, and 4th fastest respectively. They received average rankings between 3.6 and 4 and received average grades from 3.3-3.8. These are all average values for this survey, indicating that highlighting alone does not affect readability in any significant fashion.

When users were asked to elaborate on their rankings, many validated their rankings by judging based on links not being 'intrusive' or too obvious, but still noticeable. Most compared the articles to what they normally see on the Web, and noted that they are already conditioned to read black text with blue underlined links imbedded, and so this is what they preferred. In a survey with a small number of participants such as this, it was interesting to note that more than one participant did not seem biased against highlighted links and said that they were noticeable, but not too striking. Overall, users said they preferred text colors that were at least moderately contrasted to the background color and a link background color that was not too contrasted with the rest of the web page's background. When it comes to the Web as a variety of web pages, users were divided. Some liked having variety and letting web page designers choose which colors to use for all aspects of the page (including links) and some said they would prefer if at least the links were consistently represented across all web pages so that there was little to no confusion what object in a page is or is not a link.

6.0 Conclusions/Future Work

In summary, the common Web user is currently conditioned to associate blue underlined text with links, and readability of web pages with this linking technique is usually enhanced due to this fact. The results of this survey were inconclusive for indicating the optimal link visualization technique, based on the varied and inconsistent rankings and read times associated with the test articles.

Users ranked fairly highly their use of the mouse to view a link's URI before following it, and to see if the mouse changes to a hand when on top of something they are not sure is a link or not. With this key, these respondents say they can adapt to any link visualization that may start being used on the web. A survey for testing how adaptable users would be to a new XML linking environment would be to change the look of the link at the same time as the functionality of the link, bringing up a pop-up so that the user can choose from a list of arcs to follow from a source XLink.

Although the results of this survey did not establish consistent results for preferred link visualization techniques, this work could be utilized on a broader scale to clarify inconsistencies associated with the nature of a small test group. Additionally, the survey could be expanded to isolate separate techniques in order to evaluate their individual effect on readability and user preferences.

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