“White Space: How much nothing should there be?”

by

James Zdralek

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Abstract

White space is the empty area between elements in a graphic composition. It is an important design tool used to separate and group parts of a web site. Recommendations about white space on the web have not distinguished the varied uses to which white space can be applied. To assist web designers, greater knowledge of the proper use of space is needed. The purpose of this study is to discern the extent that varying the amount of “gutter white space” used in the design of a web site affects the speed of in-page navigation. Success rate and time lapse were used as performance measures while varying the amount of white space between the groups of content items on several different web site designs. “Page navigation” was used as a basic task from which the effects of white space were separated into visual and motor responses by using a “link pointing” task and “visual search” task as well. Designers and non-designers were studied to determine whether expertise in a visual design skill affects the response to white space.

No differences were found, indicating that a change to the gutter white space on a web site affects neither designers nor non-designers. The separation of the tasks was reexamined concerning the size of the links chosen at random for the experiment. It was found that the separation of the task into components was a valid method of researching web navigation behavior but this exploration also uncovered a possible confound. The effect of target size on the visual search component of the task was opposed to the link-pointing component.

The lack of an effect on task time does not mean that crowding a website with as much information as possible is warranted. Judgments about the use of white space and aesthetics should be balanced with the density of information needed to attract the user without impeding usability.

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White Space: How Much Nothing Should There Be?

Nothing can replace white space. The importance of the correct amount of space between objects can be articulated by the most inexperienced graphic designer. This thesis was inspired by the triviality attributed to white space outside the design profession, which could be remedied by a better understanding of the influences of white space. What follows is a historic context of white space and its use in design. Different uses of white space are distinguished and reviews of previous research and related theories are presented. As well, issues that constrain studies of white space, in particular those that effect web navigation, are covered.

The empty areas between objects in graphic compositions are used to separate and group elements. This space is an important design tool and can affect everything from mood to eyestrain. White space can be used in advertising to create a sense of elegance by surrounding the subject with an excessive amount of room. It can also be used to create associations between objects by grouping them closer together than other objects. Space is everywhere from the edge of the text on the side of this page to the space between these letters. Standard terminology for this space comes from typography where margin, gutter, leading, tracking and kerning each have settings in most page-layout programs. Any person creating a document can change these parameters and affect the readability of the text, either causing their audience a headache or making subtle statements about the content. Thankfully, this freedom to affect readability is attenuated. Bartram (1982) wrote about how the attributes of a printed page can be varied within “fairly wide safety-zones” without adversely affecting legibility. The ease with which most people can detect an uncomfortable combination of spacing ensures the use of reasonable amounts of space. The ability to manipulate white space in various ways results in different aesthetic effects and shows that space is indeed designed.

Designers are trained to understand the effects of space and to use it appropriately. Training for this type of expertise was originally passed as craft from typographer to apprentice in the ancient print shops of the past. A similar method is still used today as graphic design students are told by their instructors which areas need more or less space in a composition. Prescribing the correct use of white space is similar to defining art. Guidelines may be appropriate for white space but, as with art, any attempt to define it solidly will fail as someone tests the boundaries of taste and the status quo. A prescription for the correct use of white space as well as the definition of art are both well beyond the scope of this thesis.

Hutt (1967) in describing the manipulation of white space in a newspaper design stated that a couple of iterations of a design would reveal “the most agreeable effect”. His argument was that, because white space is an optical effect, its evaluation is best done by viewing the designs. How can appropriate spacing be seen so easily but be so difficult to describe? The German font company URW, Unternehmensberatung Rubow Weber, developed digital methods for kerning between letters that underwent a great deal of iteration. (Karow, 1998) A "viscous liquid" theory was developed which explained proper kerning as the distribution of a set amount of viscous liquid between the forms of the letters. The viscous liquid would spread between the letters but not into the deep crevasses of C's or E's.

White Space and the Medium

The history of margins originates with the sheaves of paper used in flat press printing blocks. The desire to print to the very edge was due to the expense of paper, but the limits of the press constrained the printer to leave a blank area surrounding the text that could not be printed on. Even when this technical issue was overcome, the ergonomic issue of thumb size presented itself. Is the book to be held in the hand or laid on the table to be read? If a book lies on the

table, text can be printed to the very edge of the page, but if it is to be held in the hands as it is read, then a margin is needed around the text to prevent the thumbs from obscuring the words.

Williams (2000) argues that people will ignore overcrowded pages. He states that this crowding is caused by designers who think that they are saying more by saturating the page with text and images. There are arguments to include space on the sides for note taking. (Spencer, 1968) As well, there are arguments for wide inner margins to avoid lines of type that curve into the crease at the spine of the book. (Tinker, 1963a) The curvature of the page into the crease causes a distortion of the type resulting in a slowing down of reading speed. There have been a few studies, but more than ample suggestions, on the optimal size for margins and size of books. Visual effects such as the part-whole illusion in which observers consistently overestimate the coverage of page with text have been studied but the implications of the effect are left to the imagination. (Tinker, 1963a) With the long history of books, this lack of defining research on basic uses of white space is foreboding.

This historic vestigial margin from the days of print has had its effect on the web. In the early years of the graphically rich World Wide Web, site design was treated like paper-based design and often done by the same people. Currently the use of white space is shrinking as designers squeeze more content and ads on the front page. This has pushed the margin to the periphery of design and has reduced the use of white space. The increasing density of information has created some backlash in the design industry where some designers argue that the tendency to present such high-density pages makes it more difficult to interact with the web.

A news site on the web has very little space left open and is often crowded with articles and ads. This can be an effect of economics, an attribute held over from the typical print layout of newspapers or simply a matter of taste. Do news sites cram it on the page more than other

sites? Common argument and a cursory glance at the Internet seems to indicate that this is true. The crowding of information creates a perception of overwhelming information. This density, by which websites can create expectations of content, represents a kind of style. Whether this style is defined by economics or just adhering to the norm is unknown.

Barnhurst (1994) refers to Walter Ong whose studies in the 1960s argue that the lack of white space in print creates the impression of final authority "leaving no room for argument or dispute" whereas adding space lessens the visual authority of the piece. Newspapers, the densest form of print, often emphasize white space as the most important factor in design. (Hutt, 1967) Perhaps at such high densities the interaction of design features, with each other or with the spacing of other elements, can produce stronger effects than amply spaced layouts. These stronger effects could be evident in the confusion that ensues when a reader loses his or her place in an article or when a line is skipped or reread. This sensitivity of tightly spaced layouts may be exacerbated on the web by the lack of control that web browsers allow over the spacing of items. Whatever the effect of tight spacing, it was not with disregard that newspapers chose to have little of it but rather the choice was made with full knowledge of the difficulties and the implementation was made with delicate skill. Hutt (1967) describes white space as of primary importance and stresses that the extremes of too much or too little are equally undesirable.

White space has an aesthetic effect that may originate from people's expectations and perceptions of what is the norm. People may have a vision of what a prototypical web site should look like or they may have several that fall into different classes of web sites. A news site may be expected to be crammed with articles, showing that the reporters have gathered all the relevant stories and have done a thorough job. When people are surfing for news, they may have

an expectation of being inundated with information. This expectation is unlikely to change due to the cost of white space. That cost is having content forced off the front page.

Barnhurst (1994) reported that between the 50s and the 70s the amount of white space in newspapers grew. This seemed to make the older generation of newspapers impenetrable. (Morton, 1986) One detrimental effect of this addition of white space to newspapers is the sacrifice made to content. As the amount of white space increased, the number of front-page stories decreased. (Barnhurst, 1994) Arnold (1969) referred to the aesthetic qualities of white space and how it seemed to make content more approachable. Take for example the white space on a government site where a page about taxation may be more inviting if it has a large amount of white space. The added space may signify that there is less to do, that the rules are simple and they can be explained fast and in simple terms.

Barnhurst (1994) noted that research into legibility increased during stylistic changes and that the research tended to support the styles and practices in use at the time of the study. He exposed a tendency to become accustomed to what is in style. The types of print we have been exposed to during childhood while learning to read may be the initiation of a system that adapts to every possible font, spacing and style of layout that a person will be exposed to over a lifetime. During that lifetime, stylistic changes are gradual but, when observed in epochal leaps, are visually dramatic. Barnhurst (1994) postulates that as designers push the limits of acceptable design and try new things they are exposing the public to new visual environments. These new graphic styles may be measurably less legible but he surmises that they soon could become the norm and thus become the standard by which legibility could be measured in the future. He rightly relegates any aspiring design rules to “mutable social practices” rather than “universal standards”.

Defining White Space

Not only do people underestimate the overall percentage of a page covered in text (Tinker, 1963a) but they also overlook white space's diversity of use. Recent examinations of white space rarely distinguish the differing effects space has when used in different ways. Space as a design tool applies to all levels within a piece of work. Within a web site, white space can be the margin between the content and the browser. It can be the gutter between text and menu. It can be open fields of blank space left empty for effect. For the purposes of this thesis, these are defined as the "macro" uses of space. On the other end of the scale are the "micro" uses of space. Word spacing, letter spacing and line spacing all affect text readability (Tinker, 1963b) at the "micro white space" level, see Table 1 for a list of white space elements in micro and macro groups.

Table 1
Macro and Micro White Space Elements

Macro White Spaces	
Margin	Space between browser and content
Gutter	Space between elements on the web site
Field	Space left blank (column ends, blocks)
Background	Space around images or display text
Micro White Spaces	
Break	Space used to define text groups
Leading	Space between lines
Tracking	Space between words
Kerning	Space between letters
Font	Space within letters

There is space within illustrations, logos and images on the page. There is space within the text, between the lines of type, between the words as well as between the letters that all interact with each other. A change to leading will affect what the appropriate font size would be

to use and would even affect the appropriate kerning. Space has many uses and it is done an injustice when it is just called “white space” without specifying the use to which it is being put.

There are many design guidelines but few of them talk about the distinct uses of white space. “Macro” use of white space, which is the use of space in major areas where it becomes an identifiable aspect, must be distinguished from the “micro” use of white space, which is the use of space in detailed areas such as kerning between letters. This distinction of scale must be separated from the use of white space to group and separate. This definition of macro and micro is a scalar segregation and does not indicate the use of one to group and the other to separate elements. This grouping and separating has a hierarchical organization that will be touched on later. The space between navigation items uses gestalt-grouping principles to separate links from other elements on a web page. Macro white space, such as the space between the navigation elements, can be used to separate the element's functions from other items on the web site. At the same time, the white space groups the elements together. The uses of white space are surmised to be distinct and broad. Any suggested use of white space or published guideline should emphasize the range of use from “macro” to “micro” as well as differentiate the use to separate groups and the use to cluster items into groups.

Definitions

There are many plausible ways to measure white space. Only one option was selected for the purposes of this study but a true understanding of white space can only be gained by examining the possible metrics that could be applied.

Figure 1. White Space Measures Based on Linear Separation

Two methods of measurement, focusing on the linear-distance separating blocks of text, are shown in Figure 1. The first example illustrates the measurement as the distance between the bounding lines of the text. This measure is the most widely used in industry due to the linear constraints of publication templates. The second measure uses the linear distance between the visual borders of a group defined by the optical effect of the ragged edge of the text on human perception. The position of this border could range from the halfway point between the shortest and longest line to the mean or median of the line lengths. The first measure uses the physical constraint of the size of the text being displayed while the second looks at an optical effect that depends on the shape of the ragged edge of the text block. The first measure would be consistent if the text were varied because of the relationship between the border and the graphic composition rule that forces text to wrap if it extends beyond that border. The second measure would vary with the text used in the composition because the border position depends on where the text ends.

Figure 2. White Space Measures Based on Volume of Separation

Figure 2 shows a couple of measures of white space not defined by a linear distance but rather an area. The first measure is defined as the amount of “viscous liquid” between elements. The unoccupied areas within the “blob” are summed up and used as the measure of white space. The second measure uses the perceived ratings of the amount of white space. This measure relates to the eye and the perceptual processes that interpret white space. This would be a qualitative measure and would not be easily obtained until the perceptual processes are more readily understood.

Figure 3. White Space Measures Based on Density

Figure 3 shows a pair of measures that use the overall design rather than looking at the amount between elements. These measures use the percentage of coverage as a means of

describing the amount of white space. The first measure is defined as the percentage of text coverage compared to the overall space available. The second definition lists the individual percentages of white, gray and black space with gray space defined as being the text and black space as being illustrations or other coverage.

Research Areas

Interest in spacing can be seen in various disciplines. Art and visual design have their own rationale and theory for spacing, which is taught in 'tradition art' or 'form and color' classes. There is also a good deal of interest in psychology, particularly in the area of reading research. (Klare, Nichols & Shuford, 1957; Lewis & Walker, 1989; Meyer, Marsiske, & Willis, 1992) Ergonomics and other disciplines have initiated some interesting research with a marked interest in warning labels and information displays. (Adams & Edworthy, 1991; Vincow & Wickens, 1993; Wilkins & Nimmo-Smith, 1987) The majority of studies on space have been done through legibility research or newspaper layout studies. (Everett & Everett, 1988; Middlestadt & Barnhurst, 1999; Tinker, 1963a, 1963b)

Foster (1973) broadened the definition of legibility to include "anything intended to help the reader see, recognize or understand a visually presented message". Using this definition of legibility, the present thesis may be said to deal with "legibility" research rather than readability or visibility. By using this definition, it can be suggested that white space changes the legibility of a web site.

Use of Margins

In a study of reading speed, Tinker (1963a) concluded that margins could only be justified by their aesthetics. Tinker compared the speed of reading text printed on paper with a 7/8-inch margin and with no margin (1/16). He concluded that margins do not promote legibility

and their use can only be justified by aesthetics. Major research in the field of legibility often stops at the edge of the text. Marginal research has been done into the space around text. This can be attributed to an obvious argument that “de minimis non curat lex” or “the law does not concern itself with trifles”. The scale of the effect that margin and gutter have on readability is possibly very weak or nonexistent (Tinker 1963b). This scarcity of published research in this area could be a result of the difficulty of finding an effect caused by white space. This contrasts with designers' interest in white space. It could be argued that designers' interest may be evidence that changes to the gutter, a macro white space, may only affect the aesthetics. However, designers use space in designs to facilitate grouping, making effective use of Gestalt principles and other well-studied effects of interest to psychologists.

Grouping, Layout and Density Metrics

Tullis developed a popular method of measuring screen density for alphanumeric displays that has been updated to accommodate recent developments in display technology. (Tullis, 1983; 1988) He broke ground in alphanumeric display evaluation by developing a method of measuring global density, local density, grouping and layout complexity. On an alphanumeric display, global density is the number of filled character locations divided by the number of potential character locations. Local density is the average of all the individual local density's calculations. Individual local density is the sum of the filled locations close to a point multiplied by their proximity.

Internet Use of White Space

In a study published by Spool, Scanlon, Schroeder, Synder and DeAngelo (1999) four categories of question were used to study the ease of finding information on web sites. These were simple facts (“How much would it cost to purchase a T-shirt?”), simple judgments (“Would

stock funds be a good investment for your aunt's retirement?"), comparison of facts ("Which wristwatch at the Disney Store is the least expensive?") and comparison of judgments ("In your opinion, what is the best new convertible for under \$20,000?"). Several questions were generated for each site and were discarded if they did not meet a completion time of 10 minutes in a pilot test. The remaining questions were then regarded as equivalent in difficulty. Of the 11 sites tested, the following two examples from an entertainment site and an investment site belong to the same simple judgment category. "Would stock funds be a good investment for your aunt's retirement?" and "Which month has the best weather for a visit to Disneyland?" After running the study with these apparently equivalent questions, the results of the post task questionnaire were correlated with successful task completions. Three questions from the post task questionnaire dealing with frustration, temporal perception and confidence were highly correlated with success and so the average of these was multiplied together to arrive at a site usability value. The variability, correlations and significance of these results were not published and attempts to contact the author failed.

Spool et al. measured white space by blacking out content and presenting the resulting image to people and asking them how much white space there was. Text density was measured by summing the number of words on the page and dividing by the length of page to get a density measure. The exact method used to measure white space is unclear and which of these measures was the basis for their research is unknown since the detailed results were not published. The study exposed a trend that showed that less white space on a site was associated with improved usability. This result was published as a guide for designers even though the study was confounded by the difficulty of the tasks and the quality of the site designs.

The effects of white space on usability found by Spool may have been entirely coincidental as shown by Bernard, Chaparro and Thomasson (2000). No evidence of a trend in usability was found in their study, which varied the amount of white space on a single web page. Bernard et al. (2000) measured usability with two methods. One looked at the time it took to click on a link in a single page and the other measured perceived usability through a post task questionnaire. The study also measured preference, and satisfaction. Three levels of white space were used and as the amount of white space was increased, the scrolling increased. Although the study by Bernard et al. (2000) found no effect on usability, it was confounded with scrolling.

Screen Based Text

Youngman & Scharff's (1993) study was a text-only evaluation in a framed box on a screen that tested reaction times to find a hidden, out-of-context, word. Three text widths and four margin sizes, equal on all sides, were tested. Two levels of one line length were not evaluated due to screen real-estate limits. The conclusion was that a small text width with a large margin or a large text width with no margin was the best for reaction times. Although this study is far removed from web usability, the task and manipulations of white space show that differences in reaction time could be discovered while controlling for scrolling.

Specific studies that look at the use of white space on the web are few and show a need for more defining research. As argued by some newspaper designers, the proper use of limited amounts of white space is more difficult. The reasons why it is more difficult and how designers overcome these difficulties should be studied so that perceptual-based theories can help support layout decisions.

*Theories Related to White Space**Gestalt Grouping*

One of the primary methods by which groups are discerned within a mass of objects is by proximity. Grouping by proximity can be utilized at many levels as can be seen in Figure 4. The groups could be either five groups of three dots or two groups of six and nine dots or both.

Figure 4. Example of Perceptual Hierarchy

This "perceptual hierarchy" (Compton & Logan, 1993) could be extrapolated to web sites. Grouping principles of proximity are operating on web sites: on elements within an illustration; between words, lines and letters; in navigation items; and between the larger groups of items such as content and navigation. Perhaps the task requirements determine which perceptual grouping is used or perhaps all levels of the grouping hierarchy are perceived.

Individuation

"Individuating" an object is being able to separate it from other surrounding objects while "resolving" an object means knowing that there is a group of separate objects even though individual objects cannot be identified. Being able to "individuate" a target (Intriligator and Cavanagh, 1997) is different from being able to "resolve" a target. An example of this would be

to look at the corner of a tall building. Without looking away from the corner, it is possible to identify that there are windows on the other side of the building but the ability to pick out an individual window, such as the fourth one in two down from the top, is difficult. As an example, try to distinguish the third bar from the left in Figure 5 while fixating on the dot.

Figure 5. Example of Resolving a Target without Individuation

This ability to resolve items in the periphery without individuation has many fascinating implications for vision research about the economics of attentional resources. Intriligator and Cavanagh (1997) theorized that attention has a much coarser resolution than vision. They stressed that visual resolution is not the limiting factor when an object is individuated. They claim that the attentional resources to individuate are affected by the space between items. The peripheral salience or conspicuity (Scott, 1993) of elements on a web site should be distinguishable to the attentional system so that planned eye movements to the location of interest are reduced.

Preference and Performance

Tinker & Paterson (1942) found that readers' opinions and preferences for type did not reflect their performance on a reading task. Although this indicates that reading rate and aesthetic judgment may not be related, the discrepancy between preference and performance

could be explained by changes in cognitive load. Perhaps the additional resources needed to perform a task that is discomforting may cause readers to speed the task along due to their discomfort. When the cognitive load is lessened, performance decreases because the subjects are more comfortable and do not feel the urge to rush through the material. If the cognitive load is increased when presented material is not preferred, then perhaps this may be a clue to the cause of this discrepancy. Bernard et al. (2000) revealed a preference for a medium amount of white space while finding no effect on usability. This shows that although preference can be strongly influenced, changes to usability measures that emphasize performance may not be present. Although the cause of performance and preference divergence is not a focus of this thesis, further research could be done in this area to help understand the uses of white space.

With such diverse principles as the psychophysical attribute of attentional resolution in the periphery, the gestalt grouping principle and individuation, it is a wonder more research into this area has not been done. All areas where white space is used have specific needs that may relate to the varying dominance of requirements for eye saccades, gestalt grouping or aesthetics. Reading may emphasize the eye saccade mechanics of spacing while visual search for navigation items may emphasize the gestalt grouping in contrast to aesthetics that may emphasize the visual tension of objects and groups. These theories and processes reinforce the idea that the use of white space in macro areas and micro areas should be considered differently. This thesis will focus on the specific use of a macro white space referred to as the gutter.

Focusing on White Space

Gutter White Space

The gutter, a macro white space, is used to separate the groups of items that compose main content, page title, logo, navigation, and featured links. This experiment will determine if a

change to gutter white space has more than an aesthetic effect. It will determine whether a detrimental effect to task time can be caused by changes to the amount of white space in the gutter between major groups of elements on a website. Although this change has obvious aesthetic effects, this author is interested in whether task time will be affected as well. Two pages varying only in gutter white space are shown in Figure 6.

Figure 6. Increasing Gutter White Space between Groups

In Figure 6, the white space between the major groups can be seen, showing a lesser amount on the left and a greater amount on the right. In Figure 7, this change is highlighted to show that the groups of elements stay the same while only the gutter between them changes. The changes to white space affect what Tullis (1983b) calls 'local' density.

Figure 7. Gutter White Space Highlighted

Definition

Gutter white space is the space between the bounding borderlines of these groups of objects. Increments to white space were selected using measures based on this definition. This definition is typical of the design constraints of web sites. The borders between groups are often defined by the largest protrusion from the group. This sets the standard for the page or site and the borders are defined according to it. Once these borders are defined, they are immutable as more pages are added to a site. Some pages will have more white space by other measures because menu items or content is shorter. Using the linear distance definition of white space will help associate the different pages of one web site. This does not reflect any perceptual definitions of white space but rather relates the results of this study to an easily understood measure that designers can interpret.

Differential Effects of Too Much and Too Little

It is proposed that there are limiting processes at both ends of the white space spectrum that may affect the usability of the sites when white space is varied. Changes to usability at the lower limit of spacing may be caused by visual tension or interference with other gestalt groups, whereas changes at the upper limit of spacing may be caused by physical distances the eye and hand have to move. There is a point at which the reduction of white space causes an overlap of items. The difficulty that newspaper designers purport to experience when "whiting" a newspaper (Barnhurst, 1951) may be related to perceptual difficulties that may increase as this overlap point is approached. As less white space is used, designers experience increased difficulty in decisions relating to its use and placement. It is hypothesized that the effect on usability of greater amounts of space is a gradual deterioration as more time is required to transition across greater distances. As well, it is hypothesized that at narrower measures of white

space a faster degradation of performance occurs, possibly because more time is required for visual search processes to distinguish groups. The effect of less white space was thought to increase more rapidly than that of the effect of more white space. These hypothetical differences are based on a floor and corresponding lack of a ceiling for the effect. This floor is reached when objects start to overlap as the amount of white space reaches zero. Conversely, a ceiling effect may not exist because, theoretically, white space can be increased to infinite amounts. In a physical sense, a limit does exist at the edge of the monitor but this is a limit of the device's stimulus range not a visual or cognitive limit.

Increment Selection

Using the above hypothesis, this study used smaller increments for the narrow white spacing and greater amounts between ample white space. Using a logarithmic distribution reduced the susceptibility of this study to the central tendency effect by preventing the middle value in the range of stimuli from becoming an "optimal amount" of white space. Additionally, the use of equally distributed levels of white space would waste resources studying the middle zone where the likelihood of finding an effect is low. Five levels of spacing were deemed appropriate to detect any type of trend in this study.

Layout Interdependence

One of the difficulties of confounding is isolating one variable. The interdependent nature of white space may make it difficult to isolate the single variable of gutter white space. Burt (1959) argues that experiments that study only one aspect of print such as leading or line length are quite inconclusive. He states that any designer would know that each element of the design is tied closely to the others and that manipulating only one ignores the interaction among them. Changing just the gutter white space may hide an effectual cause that can be sourced to

the initial design used to generate the incrementally spaced designs. The spacing used within the objects on the web site may have been chosen to work with the spacing between the objects.

Through casual observation and personal experience, it seems that designers perpetually fiddle with their designs. This may be evidential of the interdependence of the design features.

Figure 8. Variation of One Design

The original design may have interdependent design features that influence usability and perceptual processes. Compared to the pages in which white space has been added or subtracted, the original design where white space has not been modified may elicit a different response, which can indicate an interaction between design elements on a page. The initial designs used in this study likely have coordination between the choice of font sizes, the color, the spacing between items and the spacing between groups. It is noted that there is a possibility of confounding between the variations of white space and that amount which is closest to the original design; see Figure 8. The interdependence of layout features is ignored due to the complications involved in controlling for it.

Scrolling

Scrolling relates to the design choices that designers have to make when choosing a layout. Adding white space to a design increases the amount of scrolling. Increased scrolling would add to the task time therefore this study controlled for scrolling by limiting the content to single pages.

Size Change Accommodation

The increase in the real estate needs of a web page, when more white space is added, has to be accommodated. Since scrolling is controlled for, there must be accommodations that allow the material to be presented on a single page. Figure 9 shows the three options for accommodation. In the first option, the web browser resizes to accommodate the increase in screen area needed. In the second and third options, the browser maintains size. In option two, the excess margin accumulates on the bottom and the right while in the third option the margin is equally distributed around the web site.

Figure 9. Three Browser Accommodations

To accommodate the changes to the size of material presented when different levels of white space are used, a decision was made between changing the margin and the browser. The first option has the possibility of confounding through a change in global density while the second and third browser accommodations can possibly be confounded by a change in the margin around the site. The second browser accommodation has the additional possible confounding of the alignment to the top left corner. Of the three options shown in Figure 9, the second one acts most like the current web browsers in use. The effects compared across these possible browser changes could relate to measures of global and local density. (Tullis, 1989) The different effects that these accommodations could have are outside the scope of this thesis

and so the central browser accommodation is used since it acts more according to the behavior of present browsers. Using a browser size that accommodates the largest web site could possibly cause that site to appear complete by filling the entire space allowed. This could make it appear more comprehensive than the sites with less white space, which leaves a gap between the content and the edge of the browser. To avoid this effect, caution was taken in this thesis to use a very large browser window, one that accommodates much more than the largest amount of white space.

Group Differences between Designers and Non-Designers

Huck and Bounds (as cited by Foster, 1973) made a comparison to print when reflecting on a study that shows that examiners with neat handwriting gave lower marks to messily written essays. Will typography have the same influence on people's perception of the content? Although this may be a valid argument, the extrapolation to typographic layout breaks down particularly in the light of the marker's expertise and range of experience. The experiment found that marks were lower when those with good handwriting marked essays with bad handwriting. Can this transfer to print where very few people have the experience and skills in typographic layout? Perhaps those people who have the experience to create well-spaced art or graphic designs exhibit sensitivity to the material more so than those people who lack the ability to create designs. The reaction of experts to changes to the layout was thought to be interesting. The marking study looked at unintentional covert reaction to handwriting, whereas this study looked at the overt usability measure of reaction time.

It has been shown that designers' interpretations of font "emotive" characteristics are highly correlated with what the public feels. (Zachrisson, 1965) Accordingly, the argument can be forwarded that if designers did not visually react or think the same way that the general

population does, then the profession would have been ostracized long ago. The difference between designer and non-designers lies in the ability to generate or visually articulate what the general population can see and interpret.

The sensitivity of a study to detect any changes to usability caused by white space may be increased by using a population that could be more receptive to its effect. The present study divides the population into non-designers and designers based on the principle that they could have differing reactions to the levels of white space.

Usability Measures

Many tasks could be used to analyze the changes to usability caused by varying the levels of white space on a web site. These include reading speed, comprehension, memory, comparison tasks or navigation through a site. Usability measures of most web site studies involve all parts of a task from beginning to end. Usability is measured as either a speed to accomplish something or success and possibly failure to complete the task. Due to the limited number of white space studies, the basic measure of reaction time on a navigation task was selected for this experiment as a measure of usability

Fitts's Law and Task Decomposition

Fitts's Law relates the movement time of a pointing task to the distance and width of a target. The formula relating the three measures is a logarithm of the ratio of the distance and width of the target. The law is quite robust and has been applied to many situations. For a very thorough review of current research, with special attention to the speed accuracy trade off, see Plamondon and Alimi (1997).

According to Fitts's Law, the addition of white space to the webpage would directly influence the task time. The change to the task time caused by the extra pointing distance could

mask other potential effects. The visual aspect of a web surfing task was thought to be the area where the influence of white space should be explored. To expose the locus of any effect, this study separated the effects of looking and pointing into different tasks. This isolates any influence that distance could have on the pointing component of navigating a web page from the visual aspect of the task, to which Fitts's Law does not apply.

Purpose of the Study

This experiment analyzes the effects of white space. There are diverse ways in which white space can be used and so this study focused on the gutter between the major groupings of elements on a web site. The performance of subjects was measured while white space was varied. Special attention was paid to the limiting processes at the narrow end of the white space scale. This study also looked at whether designers would show more sensitivity to changes in the layout than non-designers.

Hypotheses

Hypothesis 1: Link pointing and page navigation take longer as the amount of white space increases.

Hypothesis 2: Visual search takes longer as the amount of white space decreases.

Hypothesis 3: Compared to Non-Designers, Designers will find a target using visual search slower as the amount of white space decreases.

Hypothesis 4: Compared to Non-Designers, Designers will find a target using visual search faster.

Method

Experimental Design

The study examined five levels of white space on five different web sites; see Figure 10. This required 25 website variations but only five website designs since the variations are adjustments to the spacing of items within the browser. Five sites were used to lessen the transfer effects that would occur when studying the same task on the same site.

Figure 10. Web Sites and White Space Variations

Each subject saw all five web sites but only one level of white space was seen on each site. Transfer effects were avoided by giving subjects a different website for each level of white space. Despite the web sites differing in content they all used the same template to position the major elements.

The “page navigation” task of finding and selecting a link was separated into a “visual search” task and a “link pointing” task; see Figure 11 [a]. These task types were performed as individual tasks by all subjects, see Figure 11 [b]. In the “visual search” task, subjects located a web page link on a screen then pressed the spacebar on the keyboard to indicate they had found the link. Pressing the spacebar blurred the web page. The subject then used the mouse to click

on the location where they saw the link. This yielded a measure of pointing accuracy; see Figure 11 [c]. A click within 15 pixels of the link location was considered successful.

Figure 11. Segmentation of Tasks

For the “link pointing” task, subjects started from a predefined position and selected a highlighted link. For the “page navigation” task, the subjects located and clicked on a web page link. The “page navigation” task was included in the study to compare the total task, which involved both searching and pointing, to the component tasks of “visual search” and “link pointing”. Accuracy was stressed for all task types. After each task, the subjects evaluated their performance; see Figure 11 [d]. The rating asked the user to evaluate how well they performed the task. Two ratings were evaluations of success while the remaining six were various possible errors. These judgments were used to identify outliers.

Experimental Design

A Latin square design was used so that each subject was exposed to each level of white space. Two balanced Latin squares created 10 orders that required a minimum of 10 subjects for a complete set. Two orders of presentation for the web sites were used to balance the order effects; A-B-C-D-E and E-D-C-B-A, which together with the 10 presentation orders for the levels of white space resulted in the 20 presentation orders (see Appendix A). This meant that 40

subjects were needed for a two-group study. After the subjects' designer or non-designer status was determined, they were randomly assigned a subject number and presentation order.

Design of the Web sites

Five web sites with three pages on each site were gathered from the Internet. They were redesigned to have the same number of menu items, internal page links, images and general layout to ensure consistency in the design. The content theme and visual design varied between web sites but each site conformed to the same basic template, see Figure 10. The menu item labels on the left side of each page were different for each task to minimize any learning effects by forcing subjects to read all labels when searching for a target. There was no scrolling.

The category and content of the web sites was controlled because expectations may affect the subject's reaction. Certain categories of content, such as news or art sites, have certain expectations for the use of white space. As well, content such as spelunking and hang gliding all bring to the mind visions of narrow confines or open spaces. These categories and content topics were therefore avoided. The content was selected to minimize expectations associated with space. The sites focused on hobbies, academia, alternate energy and food preparation.

Random Assignment and Selection

The site's pages were randomly selected for assignment to the three task types. The area of the target link was then randomly selected from three positions, specifically, the top navigation bar, the left navigation bar and the content area. The target link was randomly selected from the links within the selected area. There are 6 top-navigation links, 7 left-navigation links and 4 content links, on each web page. The length of the link names ranged from 4 to 23 characters (see Appendix B). For the link-pointing task, a second area was selected from the two remaining areas and then the start position was randomly selected from the links

within that area. This ensured that the path between the start point and end target of the link-pointing task would cross the gutter white space that was varied. The angle and distance of travel would change for each variation of white space (see Appendix C). The accuracy of clicking on these links was evaluated at a distance of 5 pixels around the link for the page navigation task and the link pointing tasks. For the visual search task, the accuracy was evaluated at a distance of 15 pixels around the link because the site was blurred when the subjects were asked to confirm the location they saw the link (see Appendix D). The independent and dependent variables as well as randomized and balanced aspects of the experimental design are listed in Table 2.

Table 2
Variables List

Independent Variables	
Amount of White Space	[5 levels] 0, 4, 12, 28 and 60 pixels
Visual Expertise	[2 levels] Designer or Non-Designer
Dependent Measures	
Response time	How long did it take to complete the task?
Accuracy	Did the click fall within the prescribed area?
Randomized and Balanced	
Assignment of the web pages to the task types	[6 matches randomly selected]
Area of target links on the web pages	[Randomized amongst the 3 areas]
Actual target links on the web pages	[Randomized amongst the 7,6 or 4 links]
Assignment of the subjects	[Randomized within the 2 groups]
Presentation Order of Task Types	[Randomized amongst the 6 orders]
Presentation Order of White Space	[10 balanced orders]
Presentation Order of Web Site	[2 balanced orders]

Planned Comparisons

The main data analysis methods were repeated-measure ANOVAs used to partial out the effects of the subject's individual variations. Separate ANOVAs were used to analyze the

measurements for the three tasks of visual search, link pointing and page navigation. Each ANOVA is a 2 x (5) design with repeated measures on one factor. The two factors are visual expertise and white space. The two levels of expertise are designers and non-designers. The five levels of white space are the logarithmically distributed increments to the gutter white space of 0, 4, 12, 28 and 60 pixels of linear separation. The analyses were used to evaluate the four hypotheses.

Subjects

40 subjects of whom 20 were designers and 20 non-designers took part. The designers were recruited from the Industrial Design and Architecture schools at Carleton University and the non-designers from the general population at Carleton University. At the end of the experimental session, the subjects were asked about their naivety towards the white space aspect of this study and asked not to discuss the experiment with anyone.

Apparatus

The experiment was run on an X86-based 700 MHz computer with 130 megabytes of RAM (see Appendix E). Macromedia Director (Macromedia, 2003) was used to integrate the profiling questions, simulations of the web sites, data gathering and practice sessions into one stand-alone application. The experiment was presented on a Samsung Sync Master 950p monitor set to 1024 x 768 pixels at 85 Hz with 32-bit color. All testing was conducted in the same testing lab. A video camera was used to record the subjects' mouse and keyboard actions.

Procedure

Recruitment

Recruitment posters were displayed in the university to attract students to participate (see Appendix F). After receiving an email or call indicating an interest in participating, the subjects

were scheduled to come in and participate. Questions regarding participation in the study were answered at the time of recruitment.

Experiment Preparation

Upon arrival, subjects were greeted and thanked for their participation (see Appendix G) and asked to read and sign a consent form (see Appendix H). A sign was placed on the door to avoid disruptions. They were shown the computer, chair and input devices and told that the use of the mouse and keyboard would be explained on the screen. A series of screens took them through the pre-task procedure (see Appendix I). On the computer screen, the subjects were greeted and asked to place the mouse and keyboard comfortably. The subjects were then asked for profile information regarding their Internet use and visual design experience. If the subject skipped the visual design expertise question, they were encouraged to answer it by a pop-up dialog box. The subjects were then informed of the general procedure of the study and steps involved. The task order was then randomly selected.

Link Pointing Task

The subjects were introduced to the task procedure with a text description as well as an animation. When they had seen the entire animation at least once, they could click the next button to continue. Through a voice-over controlled by the computer, the subjects were informed of the steps. The web page was exposed and then the red dashed line was faded in and the subject told to remember where the link was, see Figure 12 [a, b]. The green start circle was then faded in and the subject was asked to click in it and to keep the cursor in that position, see Figure 12 [c, d].

Figure 12. Link Pointing Task Stages

The subjects moved the cursor over the green circle and clicked. They were informed that these circles would disappear but to keep the cursor in the current position, see Figure 12 [e, f]. An automatic warning would sound if they strayed outside the start circle and they would be asked to start again by a voice over. The start and end circles would reappear and they would start the task again by clicking in the start circle. If they stayed within the start circle, they were told by the voice over to wait for a go signal before clicking on the previously circled target link. The red and green circles faded and then disappeared. The subjects waited until the beep was heard. Once the beep sounded, they moved to and clicked on the link that was previously circled with a red dashed line, see Figure 12 [g]. Task time was measured from the start of the task, when the start sound is played, to the time of the first click. Success or failure was measured by a boundary around the correct link. Once the task was performed, the subject was asked to evaluate the quality of their action. The subject was encouraged to answer this question if they skipped it. When all three practice-sessions were complete, a voice over made an announcement

to that effect and the text changed to reflect the new section of the experiment. The task was repeated for the five different web sites. Depending on the task, the text on the click evaluation screen differed. Separate dialog was used if the same task was to be repeated but on a different web site, if the task was complete but there were other tasks to do and if all tasks were complete. The screens used to explain the procedure are available in Appendix J while the actual targets are available in Appendix D.

Page Navigation Task

The introduction method was the same as the link-pointing task except for the content. The subject was shown the link name and reminded that emphasis was on accuracy. The mouse always had the same starting position because the subjects clicked a button to confirm that they were ready for the next task. When they clicked on this button, the search criteria would disappear and the web page would be exposed. Task time was measured from the start of the task, the click when the web site is exposed, to the next click. Success or failure was measured by a boundary around the correct link. Once the subjects clicked on a link, they were asked to evaluate the quality of their click. The dialog changes to the task quality evaluation and for the repetition on the five web sites within the task are the same as the link-pointing task. The screens used to explain the procedure are available in Appendix K.

Visual Search Task

For this task, the introduction method was the same as the page navigation task. The subject was asked to visually search for a link. This time the subject was asked to press the space bar with both hands to start and stop the search task. They were told that the page would be blurred and that they would be asked to indicate where the link was seen. The cursor was hidden during the visual search. The subjects were shown the link name and asked to memorize

it. They were asked through a voice-over to put both hands on the keyboard. When the subject was ready, they pressed the space bar, which exposed the web page. The subjects searched for the link and pressed the space bar again when they were sure that they had found it. The measure of the visual search task time was from the space-bar key-press that exposed the site until the space-bar key-press that blurred the site. The subjects were asked to indicate where the link was by clicking on that location with the cursor. It was considered a successful search if the click was less than 15 pixels from the correct link. The user was again asked to evaluate the quality of the search by selecting from a variety of possibilities. The text changes to the task quality evaluation and repetition on the five web sites within the task type are the same as the link-pointing task. The screens used to run the visual search task are available in Appendix L.

Experiment Termination

At the completion of all the tasks, subjects were asked about whether they noticed changes to aspects of the web site designs and about their naivety towards the study. They were given a short explanation of white space and how it was the parameter being tested in this study. They were asked not to discuss it with anyone. The subjects were informed they were done and thanked (see Appendix M). The experimenter then asked them if they had any questions (see Appendix N). The experimenter thanked them, gave them a contact sheet for questions or concerns, paid them and asked them to sign a receipt (see Appendices O and P).

Results

In this section, the task differences are first analyzed to confirm that the separation of the task into pointing and searching did in fact follow the expected logic of summation. Following this, the self-evaluation of the subjects' clicks was examined. This led to adjustments of the task differences analysis. This was followed by an analysis of the individual tasks and the effects of white space. The pointing task is then re-analyzed to ensure validity in terms of the expected confirmation of Fitts's Law.

Summation of Task Components

The means and standard deviations of the three tasks show two effects of separating the tasks; see Table 3. Of the 200 possible data points for each task, 5 were excluded from the page navigation task, 7 from the visual search task and 1 from the link-pointing task. All exclusions were due to failure to complete the task correctly. As expected, the link-pointing task is a fraction of the time of the combined task of page navigation. Unexpectedly, the means of visual search and page navigation are very similar and the standard deviation of the visual search task is much larger.

Table 3
Frequency, Means and Standard Deviations for Tasks

Task	Task Time		
	N	M (ms)	SD (ms)
Page Navigation	195	4459	2481
Visual Search	193	4430	4330
Link Pointing	199	1486	377

A one-way ANOVA performed on these three tasks was significant $F(2,584) = 69.71$, $p < .001$. Posthoc multiple comparisons using Least Significant Differences show that the link pointing task was significantly faster than the visual search ($p < .001$) and page navigation

($p < .001$) tasks. There was no significant difference between visual search and page navigation see Appendix Q, Table 8.

It was expected that the separation of the visual search component from the page navigation task would result in a shorter task time and similar standard deviation. The substantially larger standard deviation and similar task time to page navigation raised a concern that the separation of the visual search task component introduced additional factors.

Outlier Detection by Self-Evaluation

Self-Evaluation of Page Navigation Task

In the page navigation task, subject's task performance assessment reflected expectations. Table 4 shows that subjects who indicated difficulty in finding the link took almost twice as long as those who indicated that they found the link quickly. The variability in the scores was far greater for the former than the latter as evidenced by the standard deviation. The mean time for 'found the link quickly' was two seconds shorter than the 'found the link' evaluation, showing that performance could be accurately evaluated. 177 of the evaluations were positive while only 18 of the 195 were negative.

Table 4
The Page Navigation Task's Frequency, Means and Standard Deviations for Subject's Click Interpretation

Evaluation	Selection Options	Task Time		
		N	M (ms)	SD (ms)
Positive	Found the link quickly.	88	3130	1253
	Found the link.	89	5218	2442
Negative	Had trouble finding the link but found it eventually.	14	6834	3155
	I found the link but may have missed.	4	8479	3130

Self-Evaluation of Visual Search Task

Similar to the Page navigation task, 170 of the evaluations were positive while only 23 of the 193 were negative, see Table 5. The means and standard deviation of the negative evaluation categories was extremely high. The large standard deviation of the evaluation ‘had trouble finding the link but found it eventually’ indicates the possible source for the unexpected similarity between the page navigation and visual search results.

Table 5
The Visual Search Task’s Frequency, Means and Standard Deviations for Subject’s Click Interpretation

Evaluation	Selection Options	Task Time		
		N	M (ms)	SD (ms)
Positive	Found the link quickly.	96	3,009	1,552
	Found the link.	74	4,000	1,799
Negative	Had trouble finding the link but found it eventually.	22	12,047	8,867
	I slipped or clicked accidentally.	1	5,097	NA

Self-Evaluation of Link Pointing Task

In the link-pointing task, most of the targets were found quickly with 193 positive evaluations out of 199 and only 6 negative, as shown in Table 6. The lack of differences in the first two positive evaluations could reflect the difficulty in making a distinction between such short times compared to the other two tasks. The mean of the evaluation ‘I clicked the link but had a little trouble’ is longer, although by only approximately 100 milliseconds. The remaining evaluation suggests that those who evaluated their clicks as ‘I moved before the beep but then I clicked the link’ may have been overly anxious and therefore had a much smaller mean task time.

Table 6
The Link Pointing Task's Frequency, Means and Standard Deviations for Subject's Click Interpretation

Evaluation	Selection Options	Task Time		
		N	M (ms)	SD (ms)
Positive	I clicked the link quickly.	140	1499	376
	I clicked the link.	53	1474	382
Negative	I clicked the link but had a little trouble.	2	1579	485
	I moved before the beep but then I clicked the link.	4	1126	161

Task Summation using only Positive Click Evaluations

The previous analysis of task performance raised concern about the large variation in visual search task time and the lack of a difference between visual-search and page-navigation task times. To investigate this further only the positive evaluations were included in this analysis. Negative evaluations across all tasks were excluded to maintain equality of treatment and to compare the average task times. This way a total of 47 data points were excluded; 18 from the page navigation task, 23 from visual search and 6 from the link-pointing task. This was in addition to the 13 already excluded for not performing the task correctly. The changes caused by these exclusions were most apparent in the visual search task. The mean time of the visual search task is shorter and the standard deviation is less than half compared to the mean time of the data points in which only the task failures were excluded, see Table 7. These analyses confirm that subject's estimates of their own performance were quite accurate.

Table 7

Frequencies, Means and Standard Deviations for Tasks Comparing All Completed Sessions and Sessions with Positive Click Evaluations

Task	Task Time					
	Completed Sessions			Positive Evaluations		
	N	M (ms)	SD (ms)	N	M (ms)	SD (ms)
Page Navigation	195	4459	2481	177	4180	2204
Visual Search	193	4430	4330	170	3440	1730
Link Pointing	199	1486	377	193	1492	377

A one-way ANOVA using the scores with positive click evaluations was significant, $F(2,537) = 139.0$ $p < .001$. Posthoc multiple comparisons using Least Significant Differences show that all tasks are significantly different from each other ($p < .001$). The large differences in the number of data points included in the analysis are of concern but the robustness of the result is validated by the Welch and Brown-Forsythe statistics, which are both stringent measures of difference, see Appendix Q, Table 8 and 9.

The removal of negative click evaluations reveals the summative relationship of the visual search and link pointing tasks. Although the sum of the means for the link pointing and visual search tasks is 752 milliseconds greater than the page navigation mean this excess can be attributed to the additional time needed to respond to the stimulus. The subtractive logic used by Donders (as cited in Proctor & Van Zandt 1994) can be applied to the sub components of the three tasks. Each task can be divided into a stimulus, the actions of the task and a motor response.

Page Navigation (PN) = See page + Look for link + Move to link + Click mouse

Visual Search (VS) = See page + Look for link + Click space bar

Link Pointing (LP) = Hear beep + Move to link + Click mouse

The simple reaction time is the time it takes to perceive the stimulus and generate a motor response.

Page Navigation Simple Reaction (PSSR) = See page + Click mouse

Visual Search Simple Reaction (VSSR) = See page + Click space bar

Link Pointing Simple Reaction (LPSR) = Hear beep + Click mouse

The simple reaction times can reveal the core operation time of each task.

$PN - PSSR = \text{Look for link} + \text{Move to link}$

$VS - VSSR = \text{Look for link}$

$LP - LPSR = \text{Move to link}$

The measures of the three simple reaction times were gathered with a baseline experiment that used the same apparatus as the current experiment (see Appendix S). Any consistent measurement errors such as a difference between the reported time that exposure occurred and the actual time that exposure occurred are removed from the core times since the same measurement errors, if consistent, would occur in both the task and the corresponding simple reaction time for the task. Inconsistent measurement errors would still affect the resultant core times.

The summative relationship between the tasks, the simple reaction times and any remaining interaction or measurement error was then converted into a formula.

$$PN - PNSR = VS - VSSR + LP - LPSR + \text{Interaction} + \text{Error}$$

After solving this equation for the remaining interaction and error, the formula was used to calculate the interaction or measurement error by inputting the averages gathered.

$$\begin{array}{rcccccccc} PN & - & PNSR & - & VS & + & VSSR & - & LP & + & LPSR & = & \text{Interaction} + \text{Error} \\ 4180 & - & 391 & - & 3440 & + & 299 & - & 1492 & + & 370 & = & -474 \end{array}$$

The remainder of 474 milliseconds is a reduction of 278 milliseconds from the previous difference in the summation of the components. This shows that a large amount of the interaction and error time can be accounted for when the task components are separated at the simple reaction time level. This summative calculation assumes that the ‘look for link’ and ‘move to link’ components are performed sequentially during the page navigation task. Subjects were observed moving the cursor around while looking for the link during the page navigation task. This may account for the half-second discrepancy but because no direct measurement of this interaction is possible, the remaining difference can also be attributed to measurement errors. These analyses indicate that task separation can be a valid method to determine the locus of an effect on web navigation behavior

Designers, Non-Designers and White Space

Although the previous analysis validated the separation of tasks, it could not be included in an omnibus ANOVA because different targets were used for each task to prevent transfer effects in the repeated measures design. As well, the number of subjects included would be reduced to 8 designers and 9 non-designers through case wise elimination because all 15 sessions

on all tasks would have to be completed successfully. Using three separate ANOVAs only requires the subjects to complete all the sessions on the particular task being analyzed.

Traditional methods of outlier detection such as a data point more than three standard deviations from the mean were not used because white space may have an effect on performance that could appear as outliers. For the same reason subjects' judgments of their clicks was not used as a method to identify outliers. Additionally, using this method of exclusion would cause the number of case wise discarded subjects to increase drastically. Sessions in which the subject did not select the right link could not be included in the analysis due to the irrelevance of the data. A separate error analysis was not warranted because the error rate was less than 5%. Errors typically occurred when the subject clicked on content text, an incorrect link name or had a memory lapse.

Analysis of the Page Navigation Task

The number of subjects in the data plot in Figure 13 includes 20 designers and 18 non-designers. 2 subjects were excluded because they failed to complete all 5 tasks at each level of white space.

Figure 13. Mean Task Times for White Space during Page Navigation

Inspection of Figure 13 suggests that non-designers appear to perform somewhat better in the middle conditions than at the extremes and the opposite occurs for designers who appear to improve at the extreme measures of white space. Hypothesis 1 claimed that page navigation would take longer at larger amounts of white space. Standard deviations ranged from 1481 to 3377 milliseconds across all subjects and so no significant effects were found in the 2 x (5) mixed-design ANOVA for subject groups (designers and non-designers) and variations in pixels of white space (0, 4, 12, 28, 60). Hypothesis 1 was therefore not supported. A full summary table is presented in Appendix R, Tables 10 and 11.

Analysis of the Visual Search Task

For this task, 18 designers and 16 non-designers completed all 5 tasks successfully. Hypothesis 2 stated that visual search time increases as white space decreases, hypothesis 3 that this would be more pronounced for designers than non-designers and hypothesis 4 that designers would take less time overall. No systematic pattern was revealed for designers, but non-

designers appear to perform somewhat better in the middle conditions than at the extremes, see Figure 14.

Figure 14. Mean Task Times for White Space during Visual Search

The 2 x (5) ANOVA was used to look for significance at the interaction between group and white space as support for hypothesis 3, and at the main effect of group as support for hypothesis 4. However, as in the previous comparisons the ANOVA revealed no significant effects. A full summary table is presented in Appendix R, Tables 12 and 13. Thus, task performance cannot be said to vary systematically as a function of variation in gutter white space, nor do these results provide evidence to support the contention that designers perform differently than non-designers. Hypothesis 2, 3 and 4 were thus not supported.

Analysis of the Link Pointing Task

For this task, 19 designers and 20 non-designers completed all 5 tasks successfully. Inspection of Figure 15 suggests that the pattern of effects of white space differs between the two subject groups at least in the 3 middle conditions. It also suggests that there was a systematic

effect of white space on designers in the first four but not the fifth condition; as white space increased, so reaction time decreased, except for the 60-pixel condition.

Figure 15. Mean Task Times for White Space during Link Pointing

With standard deviations ranging from 296 to 422 milliseconds across all subjects, the variation in the data for this task was much smaller than the page navigation and visual search tasks. Even with the brief task times compared to the page navigation task the 2 x (5) ANOVA yielded no significant effects. Hypothesis 1, stating that link pointing would take longer at greater amounts of white space, was not supported. A full summary table is presented in Appendix R, Tables 14 and 15.

Fitts's Law Confirmation

Hypothesis 1 was a test of Fitts's law. The previous analysis considered only the amounts of white space and subject groups, but did not account for the variations in individual targets. According to Fitts's Law, performance on the pointing task is dependent on both target size and distance. The data were further analyzed to evaluate these effects. No analysis of Fitts's Law for the page navigation could be performed because the target distance would change as people

moved their mouse during the task. As well, Fitts's Law applies only to pointing tasks and so no analysis was performed on the visual search task. Only the link-pointing task was analyzed in the context of Fitts's Law.

Link Pointing Target Distances

The target distance varied for two reasons; the first was the random selection of links on the page, the second was the manipulations of white space. For these reasons, the distribution is not random and clusters of data points can be seen in Figure 16. Fitts's Law predicts that task time increases as the distance to the target increases. Entering the distance to the target link as an independent variable in a linear regression resulted in a significant correlation ($R^2=.054$, $b = 0.233$, $p<.01$), which is consistent with Fitts's law.

Figure 16. Regression Line for Task Time as a Function of Target Distance for Link Pointing

Link Pointing Target Sizes

A second aspect of Fitts's Law predicts that as target size increases, the task time decreases. For the link-pointing task, the variation in target size was measured as the number of characters of the link name. This ranged from "Arts" at 4 characters to "fermentation" at 12 characters. For a detailed list of targets see Appendix B. Using the target link's character size as an independent variable in a linear regression, a significant correlation was found ($R^2 = .027$, $b = -.166$, $p < .05$). Thus, as the target size increases, the time to complete the pointing task decreases; see Figure 17. These results are consistent with Fitts's law even though other factors are causing a high degree of variability.

Figure 17. Regression Line for Task Time as a Function of Target Size for Link Pointing

The focus of this experiment was white space and so specific experimental controls were not enacted to help analyze Fitts's Law, therefore no attempt was made to confirm adherence to the specific magnitude expectations.

Target Size in Visual Search

The significant result of the target length in the Fitts's Law analysis brought to light the possibility of a confounding factor. Target distance may have no relevance in a visual search task but target size does cause concern. The effect of character length on a word-matching task is known through several studies that have shown that as letter length increases the task time also increases. (Lee, 1999)

Similar to the link-pointing task, the variation in target size during the visual search task was measured as the number of characters of the link name and ranged from 7 to 16 characters. Using the target link's character size as an independent variable in a linear regression no significant correlation was found. This was expected due to the extremely large standard deviation of 4477 milliseconds that was previously discussed in the task decomposition. This variation prompted the use of two methods to reduce variability. This first was to use only the scores with the evaluation of 'found the link' and 'found the link quickly' thus eliminating scores with extreme values. The second method reduced the variability caused by individual differences. This was accomplished by creating Z-scores of each subject's results and using these in the linear regression. A significant correlation was found ($R^2 = .088$, $b = .296$, $p < .001$). As the target size increases, the task time of a visual search increases; see Figure 18.

Figure 18. Regression Line for Z-Scores of Task Time as a Function of Target Size for Visual Search

To compare the results to the link pointing task the same two methods were used to reanalyze the link pointing tasks regression. Doing this reduced the variations caused by outliers and by the individual differences between subjects. A significant correlation was found ($R^2 = .081$, $b = -.284$, $p < .001$).

Figure 19. Regression Line for Z-Scores of Task Time as a Function of Target Size for Link Pointing

Fitts's Law predicts that as target size increases task time decreases. The opposite effect is expected through word-matching task studies. An indication of these opposing expectations can be seen by comparing the slope of the two regression lines in Figures 18 and 19. A linear regression using the target lengths in the page navigation task was not significant. The distribution of target letter lengths was unequal between these two tasks. It is evident that confounding did occur which acted in opposite directions on the two tasks and did not act or was canceled out in the composite task. No hypotheses were put forward nor were any experimental controls applied to distribute the range of target lengths equally but the results seem to be conclusive. Target length has distinctly opposite effects on the visual search and link pointing tasks of a web surfing task when subjects are searching for a known link.

Discussion

This experiment provided no support for the hypothesis that designers respond differently from non-designers or that alterations to the gutter white space on a web site affects the task performance time. These results confirm Bernard et al. (2000) but do not support the study by Spool et al. (1999). The Bernard et al. study varied the amount of white space on a single site and found that there were no changes to usability. Unfortunately, their study did not control for scrolling. The study by Spool et al. on the other hand did not manipulate the websites and found that as white space decreased the usability increased. That study did not distinguish between the uses to which white space could be applied nor did it control for the inherent usability of sites. The present study manipulated the sites while the content was kept constant. Subjects were exposed to identical sites except for the addition or subtraction of gutter white space ensuring that confounding with site design was limited.

Designers and Non-Designers

Previous research has suggested possible differences between designers and non-designers. (Bartram, 1982; Kozbelt, 2002) These studies looked at visual cognition and semantic judgments while the present study looked at task time. The results of this study indicate that the differences that designers exhibit in cognitive terms may not be manifested as systematic differences in performance time.

Fitts's Law

According to Fitts's Law, the link-pointing task should have a predictable relation between the amount of white space and task time. This was not confirmed by examining the changes caused by the manipulations of white space. It was however confirmed in principle by the distances separating the individual targets.

Examining the size of the targets indicate a possible competing factor for Fitts's Law in the context of web navigation. The link-pointing task benefited from longer link names while the visual search task benefited from shorter link names. This contrasts with the page navigation task, which showed no effect of character length of the target links. This finding suggests that the two component tasks of link pointing and visual search have competing needs for target size that cancel out when combined into a page navigation task. The shorter target links possibly benefited the visual search task by being easier to hold in memory. The character length of the link was not the focus of the study, and so statistical and experimental controls were not in place. Confirmation through a study of target length is needed to validate the different affects on visual search and link pointing.

Scale of Effect

The confounding factor of target size may have compromised the ability to determine if white space has an effect. It is possible that a small-scale effect could be masked by the variability of the task times. Even if most of the variability were accounted for, the effect could be so small as to be inconsequential. This would be a misinterpretation to conclude that all white space is inconsequential. However, it may show that one component of a layout can be manipulated to extreme values without effect. The overall design may act as a buffer, which can absorb the changes to usability caused by manipulation of one aspect of the design. In effect, single components of a design can be inconsequential much as a single instrument can be inconsequential in an orchestra. An experiment needs to be designed that analyses the effects of each design element of a web site in concert to determine whether the elements interact with each other. The possibility of an interaction between elements is consistent with the importance that designers place on "unity"; a concept that all design elements should work together. Perhaps

unity is the buffer that absorbs the manipulation of the individual design elements, which could explain how a collection of inconsequential components becomes an effective design.

Observed Behaviors

Success of Training Tasks

The use of animation as part of the experimental apparatus was a very successful technique for task-based instruction. Only a few subjects needed assistance and even fewer had difficulty after the three practice sessions.

Automated Reach

When subjects were performing the visual search task, some of them automatically reached for the mouse once they had found the link. This was because the required action, of clicking the spacebar when the link was found, is a deviation from actual web navigation behavior. The automated behavior of reaching for the mouse instead of clicking the space bar could explain the increase in errors as well as the increase in standard deviation compared to the other tasks. This behavior was not predicted by observing the pilot tests and therefore was not an option in the post task evaluation. In further experiments, the method should be modified so that the web site is displayed when the spacebar is pressed. The spacebar would then be held down for the duration of the search and then released to indicate completion of the task. This way, automatic reaching would not interfere with the measurement of task time since the reaction is triggered by finding the link and this would be recorded when the space bar is released.

Anticipation on Fade

Some participants were over-zealous in the link-pointing task and moved before the beep. This seemed to be an effect of the salience of the fade being interpreted as a signal to do something. Anticipation of the start cue is also a possibility since the beep would activate at a

random amount of time between 2 and 5 seconds after the fade. Any detection of an unintended pattern in the order of the random times may have cued people to act after an anticipated amount of time. No improvement can be suggested to alleviate the issues. However, it was observed that the occasional subject preempted the beep and did not select that option from the self-evaluation. Further research should automate the collection of data on preemptive movements since they could be used as a way to group results to reduce variability.

Blindness to Location

Occasionally it was noted that people became “link blind” and could not find the target. Casual observation and postulation suggested two plausible causes. People could have looked at an area, missed the target and then discounted that area from further investigation. The search pattern would have to be reset and the area inspected a second time to find the target. Another noted possibility was that the cursor location could have been anticipatorily deemed as void. This is not referring to occasions when the cursor physically obscures a link but rather the occasions when the cursor ended up near the link through undirected cursor movement such as moving the arm to a neutral position. It seemed that the cursor had become an indicator for a previous search zone. Perhaps the unvoiced internal logic would sound like this. “The cursor is in that area. If the link were there, it would have been clicked on by now. Therefore, that location will not be searched.” These causes are pure speculation but occurrences of link blindness likely increase the variability in the results and should be categorized as outliers. The reduction of variability by identifying possible search anomalies would benefit research into web navigation. Further research would be needed to confirm these concepts and develop a method of identifying their occurrence so that they could then be flagged as separate distinct events.

Method Improvement

Target Standardization

The major confound in this study is the size of the target. This should be controlled in any further study involving navigation so that variation due to memory load or the ease of clicking on the target can be controlled. Comparing the effects of target size on the task components of navigation would also be an interesting area to study. Implications from reading research suggest that the prevalence of a word is another factor that can influence the speed of recognition. The theory is that a common word such as “broccoli” is recognized faster than uncommon word such as “rutabaga” even though they have the same character length. This could be influential in a search task and should be considered when selecting target links in web navigation experiments.

Designers and Non-Designers

The lack of differences in performance between designers and non-designers brings to question whether using this categorization as a grouping measure is prudent. Designers may be choosing their careers due to social pressure or other causes quite removed from visual ability. Creative ability could be more important to these professions than visual skill. It is surmised that visual skills would have more influence than creativity on a web surfing task therefore using a method to distinguish groups based on visual skill rather than creative skill is proposed. The concept that one group may be more sensitive to visual stimuli is prevalent in research concerning cognitive and perceptual styles. (Savarese & Miller, 1979; Berthelon, Mestre, Pottier & Pons, 1998) Perhaps using a measure of visual or cognitive style rather than profession as a grouping factor would improve the distinction of a between groups measure in web navigation research. Although recruiting subjects by profession is easier, there are short tests available to

determine visual cognitive style. Further investigation would be needed to identify which of these would have the strongest relationship to web navigation.

Task Decomposition

Separating the link-pointing task from the visual search task was a strategy used to expose any suppression that may have occurred between the task components that would not have been exposed in the composite task. The focus of the research was white space and no effects were found in any task. Examining the confounded aspect of the character length of the link did show an interesting trend. The discovery of the divergent effects of target length can be used to validate the effectiveness of the decomposition of the task as a tool for research.

Improvement is possible in the simple reaction time measures, which were gathered through a separate baseline experiment. Further experiments concerning web navigation that use this method should include the measurement of the simple reaction times as part of the main experiment. This would clarify the relationship between the task components by reducing the variance caused by the reaction time components. Depending on the differences measured in further experiments using this method, changes to behavior could be attributed to the visual search, link pointing or the interaction between them.

Task Linking

Further research in web navigation using this method would benefit from modifying the task decomposition so that the tasks could be associated methodologically. Using the same page and link for all three tasks would introduce a learning effect but the benefit would be that the study could logically link the tasks and include task type as a factor in a larger ANOVA. This would allow a new study to account for the summative relationship of the tasks and explore interaction effects that may not be readily apparent in separate ANOVAs.

Text Oriented Task

Even though words were used as the target links, reading for content was not a component of the task. Comments from subjects showed that they tended to ignore the images and visual material during the experiment. Perhaps this reveals how focused the subjects were on the word matching nature of the task. If a true web task were to be used in a study of this nature it would likely involve more than finding a matching word on a web site. The subjects could be given a description of the information that they would look for. The task would then emphasize word association and could be highly confounded by the vocabulary size of the subjects. For this experiment, the choice to give the user the exact phrase of the link was to reduce variability but this choice also reduced cognitive load.

Generalizing the results

The effect of the target size is predictable with Fitts's Law. The effect of character length on a word-matching task is known through word-matching studies. (Lee, 1999) What is not known is how web surfing behavior is affected by the character length of the link. This is because in a true web surfing experience the target link would not be known prior to identifying it on the page. This means that the target link would not have to be stored in memory or character matched. This study, with the use of a word search task, can be generalized to the situations where web surfers are searching for specific link names. This study cannot be generalized to situations where surfers are searching for information and must evaluate the consequences of following a link. The method of giving the subjects the exact link name is useful for web research that needs to control for vocabulary and language experience. It must be emphasized that using this method does not activate vocabulary and comprehension subtasks.

Cognitively Loading Task

To mimic a web-searching task, subjects could be cognitively loaded so that fewer resources are available to perform the tasks. During true web navigation, subjects are accessing vocabulary resources and using comprehension to evaluate page content and links. In an experimental situation, the task time could be confounded by vocabulary size and language experience. Using a distraction task such as counting, tapping or listening for words could be used to load the subjects cognitively. The task would then resemble a true web surfing experience in terms of cognitive effort but the confounding effects of the subject's vocabulary would be removed.

Conclusion

This study indicates that no change to task time occurs as gutter white space is varied. The measurement of task time did not reveal all the effects that white space could produce. In fact, it revealed only a small segment of the possible effects. Task time is the most rudimentary measure of usability. Usability is composed of many parts of which efficiency is only one. The lack of an effect in task time does not validate the overcrowding of a web site. Crowding a website with as much information as possible was not evaluated with this thesis. No specific recommendations can be made about the use of all types of white space on a web site. Judgments about the use of white space and the associated aesthetic effects should be balanced with the density of information needed to attract the user without impeding usability. Careful consideration should always be made about the effects of the added scrolling or the distribution of information across multiple pages caused by added white space. Aesthetics still seems to be the only justification for white space beyond that needed to group or separate elements.

Future Research

Several studies are still needed to determine whether white space influences usability. The various micro and macro uses of white space still need to be examined with respect to task time effects. This study covered just one of these.

Illusory Confusion or Visual Tension

Another possible effect of white space is the activation of perceptual processes or illusions that cause discomfort. Visual tension is a term used by designers to describe when something does not look right due to proximity to edges or other objects.

Figure 20. Example of Optical Illusion

Very little psychological research has been done on what designers call visual tension. There has been little or no research to find a measure let alone a cause. What psychologists call an optical illusion, such as the black smudges that appear between the black squares in Figure 20, may be a source of what designers call visual tension. Illustration has been around for some time as evidenced by ancient images that have been discovered in numerous caves. From an evolutionary psychology point of view, the visual system is optimized for three-dimensional object recognition and detection of movement. Illustration is a relatively new phenomenon and “illusions” may be a side effect of our visual environment changing faster than the genetic code

that structures our visual system. The saturation of our environment with sharp contrast print on flat surfaces is a relative recent phenomenon. Little in the way of adaptation of the visual system could have occurred since the development of ink and paper.

The visual processes that help in identifying predators hiding behind trees or helps locate tasty treats in the branches nearby may be activating through happenstance and the accidental arrangement of images and type. There are many other basic visual processes such as reification where an object, occluded behind something, is completed by the visual system. The size contrast illusion, occlusion, perceptual reification and illusions may all be contributing in some way to visual tension. Visual tension could be an effect of perceptual processes activating at low levels below illusion, or it could be merely a conscious judgment as to whether things are cluttered or sparse. Whichever explanation is used the fact remains that designers often talk of this effect. The source of the effect may not be explainable but is certainly affected by the use of white space. Whether designers are more sensitive to these illusions and use this skill to adjust space and position to reduce the effect is unknown, but the idea is another fascinating area of research for those interested in the use of white space and designers' manipulations of it.

Eye Movements

Eye movement may play a role in the importance of white space in design. The eye fixates at a location of interest and can gather detailed information about the objects within a measurable range around the fixation point. The gathering of feature information from the periphery may benefit from the use of space. (Scott, 1993) Eye saccades, the transition of the eye from one point of interest to the next, are shorter when reading tightly spaced text. (Arnold, 1969) An appropriate analogy was made by Arnold (1969) to explain this effect. By driving the same distance on a clear road as compared to a road with many stoplights, the road in which a

driver is repeatedly forced to come to a halt and then regain speed would be obviously less economical in terms of time and resources. Many shorter saccades are more time consuming than a few long saccades because the time to start and end a saccade is longer than if the eye movement continued further.

Much has been said by designers about their justification of the use of white space. Using white space to reduce fatigue could be pursued with further research; one may also logically argue that space gives the eye way finding landmarks by which to navigate. The efficacy of space in text is refuted by Epelboim, Booth & Steinman (1992) but supported by Findlay (1981) as well as Rayner, Fischer & Pollatsek (1994). If increased spacing helps the eye in the process of gathering peripheral information and makes it easier to select a target then the distance that the eye travels per saccade may be longer not just due to the extra space between items but perhaps because the space helps the eye target items at further distances. This could mean that if space is put between items, the saccades become longer but are longer than the extra space added. The longer the saccade the less set-up time is needed for the eye to travel around the interface. This reduction in time may be minuscule but over an extended period, the longer saccades in reading may reveal themselves as an increase in performance. If saccade length can be associated with white space in a web site navigation task, while still accounting for the greater distance, then this association may indicate an effect that could be too small to be measured in standard usability tasks but may manifest itself in longer-term effects such as eyestrain and discomfort.

Time Estimation

Prospective duration judgments are estimations of the time taken to perform a task, knowing beforehand that an estimate will be requested. Sawyer, Meyers & Huser (1994) stated

that duration judgments are affected by task demands. The theory is that there are resources needed to maintain a "cognitive clock", which are shared with the tasks being performed. Sawyer, Meyers & Huser (1994) theorized that a cognitive clock would increment whenever attentional resources are available and that time estimation was a function of these accumulated increments. In a study of white space, time estimation could be used to gauge cognitive load to look for other effects beyond physiological changes to motor control. Prospective duration judgments could give a reasonable estimate of the attentional resources used to perform the three tasks. This would be useful since it has been shown by the present study that changes in the overt performance of the task may be too small to be detected. As well, visual expertise could be reexamined as implicated by Michon's study (as cited in Thomas & Weaver, 2002) which concluded that time judgments were influenced by the expert and non-expert character of the subjects.

Time Estimation and Aesthetics

Aesthetic appeal was not included in this study because the effect is known to designers and would have been an adjunct to the study rather than a focus. A quantified measure of the effects of white space on appeal will have little value until the value of appeal in usability is quantified.

The measure of the perceived time while interacting with a piece of art has been shown in Gerald, Cupchik & Gebotys (1988) to be related to the amount of perceptual or cognitive effort needed to appreciate the art piece. This gives support to the idea that the effects of white space may be exposed in people's "cognitive effort" which could be measured through a change in the estimation of the amount of time taken to perform usability tasks. Changes to the actual task completion time may not be evident due to the standard physical movements involved in web

surfing. However, it is possible that effects on people's cognitive load will appear in their estimations of time to complete these tasks.

These cognitive load effects could be compared to aesthetic judgments to determine if they are related. If aesthetic appeal does in fact relate to cognitive or perceptual workload, it would invigorate research in aesthetics. Rather than vague artistic merit, concrete value could then be attributed to good aesthetics through measures of workload. The value of well-placed white space might then be more apparent and the usability community may start treating white space as something more than nothing.

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Appendix A – White Space Order Combined with Site Order

1st	2nd	3rd	4th	5th
A1	B2	C5	D3	E4
A2	B3	C1	D4	E5
A3	B4	C2	D5	E1
A4	B5	C3	D1	E2
A5	B1	C4	D3	E2
A5	B4	C1	D3	E2
A1	B5	C2	D4	E3
A2	B1	C3	D5	E4
A3	B2	C4	D1	E5
A4	B3	C5	D2	E1
E1	D2	C5	B3	A4
E2	D3	C1	B4	A5
E3	D4	C2	B5	A1
E4	D5	C3	B2	A1
E5	D1	C4	B2	A3
E5	D4	C1	B3	A2
E1	D5	C2	B4	A3
E2	D1	C3	B5	A4
E3	D2	C4	B1	A5
E4	D3	C5	B2	A1

Appendix B – Target Names and Length Attributes

Task	Use	Link Name	Character Length	Words
Visual Search	Practice 1	Tidbits	7	1
Visual Search	Practice 2	Cookies	7	1
Visual Search	Practice 3	Unpasteurized honey	18	2
Visual Search	Site A	Sports Facilities	16	2
Visual Search	Site B	Holiday Turkey	13	2
Visual Search	Site C	Garden Railroad	14	2
Visual Search	Site D	Updates	7	1
Visual Search	Site E	Tuition Fees	11	2
Page Navigation	Practice 1	Organic Kamut Flour	17	3
Page Navigation	Practice 2	Gluten Free	10	2
Page Navigation	Practice 3	Breads	6	1
Page Navigation	Site A	UCSC's academic offerings	23	3
Page Navigation	Site B	Cookware	8	1
Page Navigation	Site C	Photo Gallery	12	2
Page Navigation	Site D	Lighting	8	1
Page Navigation	Site E	AAS program	10	2
Link Pointing	Practice 1	Breads	6	1
Link Pointing	Practice 2	Muffins	7	1
Link Pointing	Practice 3	Information	11	1
Link Pointing	Site A	Arts	4	1
Link Pointing	Site B	fermentation	12	1
Link Pointing	Site C	locomotive	10	1
Link Pointing	Site D	Updates	7	1
Link Pointing	Site E	Click here	9	2

Appendix C – Link Pointing Task Attributes

Use	White Space (Pixels)	Angle (Degrees)	Distance (Pixels)	Horizontal (Pixels)	Vertical (Pixels)
Practice 1	NA	73 L	453	433 L	132 U
Practice 2	NA	132 L	464	347 R	308 U
Practice 3	NA	5 L	342	28 L	341 U
Site A	0	104 L	628	611 L	153 D
Site A	4	104 L	633	615 L	157 D
Site A	12	105 L	641	623 L	165 D
Site A	28	106 L	662	639 L	181 D
Site A	60	107 L	704	671 L	213 D
Site B	0	166 L	359	90 L	348 D
Site B	4	166 L	363	90 L	352 D
Site B	12	166 L	370	90 L	360 D
Site B	28	167 L	386	90 L	376 D
Site B	60	168 L	417	90 L	408 D
Site C	0	112 R	325	304 R	121 D
Site C	4	112 R	326	304 R	125 D
Site C	12	113 R	330	304 R	133 D
Site C	28	116 R	336	304 R	149 D
Site C	60	121 R	352	304 R	180 D
Site D	0	51 R	477	368 R	304 U
Site D	4	51 R	480	368 R	308 U
Site D	12	50 R	484	368 R	316 U
Site D	28	48 R	495	368 R	332 U
Site D	60	45 R	515	368 R	364 U

Note. Angle measures in degrees: 0, straight up; 180, straight down; L, counter clockwise from vertical; R clockwise from vertical. Horizontal measures in pixels: L, target is to the left; R, target is to the right. Vertical measures in pixels: U, target is towards the top; D, target is towards the bottom.

Appendix C – Link Pointing Task Attributes (Cont.)

Use	White Space (Pixels)	Angle (Degrees)	Distance (Pixels)	Horizontal (Pixels)	Vertical (Pixels)
Site E	0	163 L	178	54 L	171 D
Site E	4	163 L	180	54 L	175 D
Site E	12	164 L	188	54 L	183 D
Site E	28	165 L	204	54 L	199 D
Site E	60	167 L	237	54 L	231 D

Note. Angle measures in degrees: 0, straight up; 180, straight down; L, counter clockwise from vertical; R clockwise from vertical. Horizontal measures in pixels: L, target is to the left; R, target is to the right. Vertical measures in pixels: U, target is towards the top; D, target is towards the bottom.

Appendix D – Pages and Targets

Practice Session Pages for the Link Pointing Task

Legend

- Start Circle
- Target Highlighting
- Success Area

Appendix D – Pages and Targets (Cont.)

Practice Session Pages for the Visual Search Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Practice Session Pages for the Page Navigation Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Variations of Site A's Pages for the Link Pointing Task

Legend

Start Circle

Target Highlighting

Success Area

Appendix D – Pages and Targets (Cont.)

Variations of Site A's Pages for the Visual Search Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Blurred Variations of Site A's Pages for the Visual Search Task

Appendix D – Pages and Targets (Cont.)

Variations of Site A's Pages for the Navigation Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Variations of Site B's Pages for the Link Pointing Task

Legend

Variations of Site B's Pages for the Visual Search Task

Success Area

Appendix D – Pages and Targets (Cont.)

Blurred Variations of Site B's Pages for The Visual Search Task

Appendix D – Pages and Targets (Cont.)

Variations of Site B's Pages for the Navigation Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Variations of Site C's Pages for the Link Pointing Task

Legend

- Start Circle
- Target Highlighting
- Success Area

Appendix D – Pages and Targets (Cont.)

Variations of Site C's Pages for the Visual Search Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Blurred Variations of Site C's Pages for The Visual Search Task

Appendix D – Pages and Targets (Cont.)

Variations of Site C's Pages for the Navigation Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Variations of Site D's Pages for the Link Pointing Task

Legend

- Start Circle
- Target Highlighting
- Success Area

Appendix D – Pages and Targets (Cont.)

Variations of Site D's Pages for the Visual Search Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Blurred Variations of Site D's Pages for The Visual Search Task

Appendix D – Pages and Targets (Cont.)

Variations of Site D's Pages for the Navigation Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Variations of Site E's Pages for the Link Pointing Task

Legend

Start Circle

Target Highlighting

Success Area

Appendix D – Pages and Targets (Cont.)

Variations of Site E's Pages for the Visual Search Task

Legend

Success Area

Appendix D – Pages and Targets (Cont.)

Blurred Variations of Site E's Pages for The Visual Search Task

Appendix D – Pages and Targets (Cont.)

Variations of Site E's Pages for the Navigation Task

Legend

Success Area

Appendix E – System Information of Computer Used for Experiment

OS Name..... Microsoft Windows 2000 Professional

Version..... 5.0.2195 Service Pack 3 Build 2195

OS Manufacturer..... Microsoft Corporation

System Type..... X86-based PC

Processor X86 Family 6 Models 8 Stepping 3 Genuine Intel ~701 MHz

BIOS Version..... Award Medallion BIOS v6.0

Windows Directory..... C:\WINNT

System Directory..... C:\WINNT\System32

Boot Device \Device\Harddisk0\Partition1

Time Zone Eastern Standard Time

Total Physical Memory 130,592 KB

Available Physical Memory 30,232 KB

Total Virtual Memory 441,268 KB

Available Virtual Memory 250,628 KB

Page File Space 310,676 KB

Page File..... C:\pagefile.sys

Appendix F – Subject Recruitment Poster

\$10

Web Surfing Experiment

I am looking for Non-designers and Designers to participate in an experiment involving web pages that will last approximately 45 minutes. Subjects will be paid \$10 for their participation.

Web Surfing Experiment
\$10 45 minutes contact James
carleton_experiment@hotmail.com
or call me at 520-2600 x 5673

Web Surfing Experiment
\$10 45 minutes contact James
carleton_experiment@hotmail.com
or call me at 520-2600 x 5673

Web Surfing Experiment
\$10 45 minutes contact James
carleton_experiment@hotmail.com
or call me at 520-2600 x 5673

Web Surfing Experiment
\$10 45 minutes contact James
carleton_experiment@hotmail.com
or call me at 520-2600 x 5673

Web Surfing Experiment
\$10 45 minutes contact James
carleton_experiment@hotmail.com
or call me at 520-2600 x 5673

Web Surfing Experiment
\$10 45 minutes contact James
carleton_experiment@hotmail.com
or call me at 520-2600 x 5673

Appendix G – Greeting Script

Hi, my name is James. Are you here to participate in the web experiment? [Wait for answer.] Thanks for coming. I am using a script so that I do not skip anything in the introduction. Let me explain a few things so you can get oriented. This room is where you will be doing the tasks. I just want to point out that the video equipment IS being used by this experiment. The cameras are focused on the computer screen, keyboard and mouse. They are not focused on you. The recording will be used to confirm the information gathered by the computer and will be destroyed after the study. The study is computer based and so the procedure and explanations of how to do the experiment are explained through voice over or animations on the computer screen. I will be here if you need any help during the experiment. I have a consent form for you to sign. This is to inform you of the scope of the experiment and that this experiment is voluntary and that none of the information gathered in this study is associated with your name. [Present informed consent form and wait.] This is your chair. I can show you how to adjust it so you are comfortable. The experiment makes use of the mouse and keyboard, which will be explained on screen through an animation. Some parts of the study have sound and you can control the volume with this knob here. To start the experiment, please follow the instructions on the screen. If you wish to ask a question or you have any difficulty, I am available. If you are doing something incorrect, I will interrupt and assist you. If I do not say anything, please feel confident that what you are doing is correct. Do you have any questions? [Wait for answer] You can begin. [When comment screen appears.] The comment box is there from a previous idea that this experiment could be done remotely. You can ignore it.

Appendix H – Consent Form

Informed Consent Form

The purpose of an informed consent is to insure that you understand the purpose of the study and the nature of your involvement. The informed consent must provide sufficient information such that you have the opportunity to determine whether you wish to participate in the study.

Present study: Improving Internet Surfing

Research personnel. The following people are involved in this research project and may be contacted at any time: James Zdralek (Principal Investigator, 520-2600, ext. 6628); Dr. G. Lindgaard (Faculty Sponsor, 520-2600, ext. 2255). Should you have any ethical or other concerns about this study then please contact Dr. M. Gick, Chair, Carleton University Research Ethics Committee for Psychological Research, 520-2600, ext. 2664) or Dr. K. Matheson (Chair, Dept. of Psychology, 520-2600, ext. 2648).

Purpose. This experiment looks at how people surf the web. Specifically it is interested in what factors can affect how people select links.

Task requirements. You will be asked a series of questions related to how often you use the Internet and your visual design background. Following these brief questions, you will be asked to perform a series of tasks involving searching and navigating the web on different websites. You will perform the experiment on your own but the experimenter is available at any time if you have any questions.

Duration and locale. The experimental session will last approximately 45 minutes. Testing will take place in Room 2498 of the Mackenzie Building, Carleton University.

Potential risk/discomfort. There are no potential physical or psychological risks in this experiment.

Anonymity/confidentiality. The data collected in this experiment are confidential. All data are coded such that your name is not associated with the data. In addition, the coded data are made available only to the researchers associated with this project. Video cameras will be used during the study to record the computer screen, mouse and keyboard. The cameras will not be focused on you. You may opt out of the recording procedure if it makes you uncomfortable. The tapes will be destroyed after the study is completed.

Right to withdraw. You have the right to withdraw from the experiment at any time without penalty. You can also choose to not answer specific questions.

Signatures

I have read the above description of the Improving Internet Surfing study and understand the conditions of my participation. My signature indicates that I agree to participate in the experiment.

Participant's Name: _____ Participant's Signature: _____

Date: _____ Video Recording: (circle one) Yes No

Appendix I – Pre Task Screen Shots

Greeting Screen

Appendix I – Pre Task Screen Shots (Cont.)

Internet Use Screen

Internet Use

Any information gathered in this study is not in any way associated with your name or any other personal identifier. Your responses are completely anonymous.

When was the last time you used the Internet?

- ☐ 0 - 2 days ago
- ☐ 3 - 7 days ago
- ☐ 8 - 30 days ago
- ☐ more than 1 month

How often do you use the Internet in a typical month?

- ☐ At least once a day
- ☐ At least once a week
- ☐ 1 to 3 times per month
- ☐ Less than once a month

What is the total amount of time you spend on the Internet in a typical month?

- ☐ More than 50 hours
- ☐ Between 25 and 50 hours
- ☐ Between 5 and 25 hours
- ☐ Less than 5 hours

When you are done click next to continue.

Next

Appendix I – Pre Task Screen Shots (Cont.)

Visual Design Expertise Screen

Visual Design Expertise

Which statement best describes you?

☐ I am a visual designer or training to become one

☐ I am **not** a visual designer

When you are done click next to continue.

Next

Appendix I – Pre Task Screen Shots (Cont.)

Important Information Prompt

Visual Design Expertise

Which statement best describes you?

☐ I am a visual designer or training to become one

☐ I am **not** a visual designer

When you are done click next to continue.

Next

Appendix I – Pre Task Screen Shots (Cont.)

Experiment Procedure Screen

Experiment Procedure

This experiment involves three different tasks relating to simple navigation on a web site. The tasks will be described with a short animation followed by some practice web pages and then the real web pages.

When you are ready to continue, click next.

Next

Appendix J – Link Pointing Task

Link Pointing Task Animation Introduction Screen

Link Pointing Task

During this phase of the experiment, you will click on a link by starting at a certain position on the screen. A web page will be shown with the start position and target areas circled.

Find the link in the red dashed circle.

Use the mouse to click in the green dot.

Keep the mouse in this location.

The highlighting will disappear.

Wait for the beep.

Click on the link that was highlighted.

Move as fast as you can but
do NOT sacrifice accuracy.

This animation explains the process
of this phase of the experiment.

Play

Stop

Appendix J – Link Pointing Task (Cont.)

Link Pointing Task Animation Storyboard

Screen 1

Voice Over: For this set of tasks, a voice over will guide you.

Screen 2

Action: Task description shown on the screen

Screen 3

Action: Hand grabs mouse and clicks on the 'next' button.

Screen 4

Action: Web Page is shown on screen

Screen 5

Voice Over: The voice over will instruct you to locate a link circled with a red dashed line. You will be asked to remember where this link is.

Action: Red dashed line fades in.

Screen 6

Voice Over: The voice over will instruct you to locate the green start circle. You will then be asked to click in the green circle and keep the cursor in that position.

Action: Green circle fades in.

Screen 7

Action: Hand moves and cursor clicks on green circle.

Screen 8

Voice Over: The voice over will instruct you that the red and green lines will disappear and to keep the cursor in the same position while waiting for a beep.

Screen 9

Voice Over: Once you hear a beep indicating the task has started, move to and click the link that was circled with the red dashed line.

Action: Red and green circles fade out, a pause and then a beep is heard.

Screen 10

Action: Hand moves and cursor clicks on previously circled link.

Screen 11

Voice Over: You will then be asked for your evaluation of the result.

Appendix J – Link Pointing Task (Cont.)

Animation Playing Screen

Link Pointing Task

During this phase of the experiment, you will click on a link by starting at a certain position on the screen. A web page will be shown with the start position and target areas marked.

Place the link in the red dashed circle.

Use the mouse to click on the green dot.

Keep the mouse in this location.

The highlighting will disappear.

Wait for the beep.

Click on the box that was highlighted.

Move the mouse as you wish but do not click on the mouse.

This animation explains the procedure on this phase of the experiment.

The circled area indicates the changes compared to the first instance of this screen.

Appendix J – Link Pointing Task (Cont.)

Animation Finished Screen

The circled area indicates the changes compared to the first instance of this screen. When the user clicked next on this screen a voice over announces, "You will now do a set of practice sessions".

Appendix J – Link Pointing Task (Cont.)

Link Pointing Task Example

Appendix J – Link Pointing Task (Cont.)

Link Pointing Task Storyboard

Screen 1

Voice Over: Locate the target link surrounded by a red dashed line. Remember where this link is.

Screen 2

Action: Red dashed line fades in.

Screen 3

Voice Over: Locate the start point circled in green. Click in the green circle and keep the cursor in that position.

Screen 4a

Action: Subject clicks in green start circle.

Voice Over: The highlights will fade out. Keep the cursor in this position until you hear a beep. Once you hear the beep move to and click on the link that was circled with a red dashed line.

Note: This voice over is used for the first two practice sessions only.

Screen 4b

Action: Subject clicks in green start circle.

Voice Over: Keep the cursor in this position until you hear a beep. When you hear it, click on the target.

Note: This voice over is used for the last practice session and the five data collecting sessions.

Screen 5

Action: Red and green circles faded out, there is a pause and then a beep is heard.

Screen 6

Action: The subject moves the cursor outside the green start circle before the beep. The red and green circles reappear.

Voice Over: You must wait until the beep before moving the cursor. Please start again by clicking in the green circle.

Note: If the user moves outside the green start circle before the beep then this voice over is played.

Appendix J – Link Pointing Task (Cont.)

Link Pointing Task Quality of Performance Screen

Practice Results

Please select the result of the task from the options below.

- ☐ I clicked the link quickly.
- ☐ I clicked the link.
- ☐ I clicked the link but had a little trouble.
- ☐ I moved before the beep but then I clicked the link.
- ☐ I think I clicked the link but may have missed.
- ☐ I slipped or clicked accidentally.
- ☐ I forgot where the link was.
- ☐ Other (Please specify)

If you are ready for another **practice session** click next.

Next

Appendix J – Link Pointing Task (Cont.)

Please Respond To Question Prompt

Practice Results

Please select the result of the task from the options below.

- ☐ I clicked the link quickly.
- ☐ I clicked the link.
- ☐ I clicked the link but had a little trouble.
- ☐ I moved before the beep but then I clicked the link.
- ☐ I think I c
- ☐ I slipped
- ☐ I forgot v
- ☐ Other (P

If you are ready for another **practice session** click next.**Next**

Appendix J – Link Pointing Task (Cont.)

Practice Complete Version of Quality of Performance Screen

Practice Results

Please select the result of the task from the options below:

- ☐ I finished the task quickly
- ☐ I finished the task
- ☐ I finished the task but had a little trouble
- ☐ I moved before the beep but then I clicked the link
- ☐ I think I clicked the link but my hand moved
- ☐ I slipped or clicked accidentally
- ☐ I dropped where the link was
- ☐ Other (Please specify):

When you are ready to continue, click next.

The practice sessions are complete. The next five tasks are on **different sites**.

[Click Next](#)

The circled area indicates the changes compared to the first instance of this screen. When the user clicked next on this screen a voice over announces, "The practice sessions are complete. The next few sessions will be on different web pages."

Appendix J – Link Pointing Task (Cont.)

Next Page Version of Quality of Performance Screen

Next Site

Please select the result of the task from the options below:

- ☐ I clicked the link quickly
- ☒ I clicked the link
- ☐ I clicked the link but had a little trouble
- ☐ I moved I before the beep but then I clicked the link.
- ☐ I clicked I clicked the link but my hand moved.
- ☐ I stopped or clicked accidentally
- ☐ I forgot where the link was
- ☐ Other (please specify)

The next task is the same but will be on a different web site.

When you are ready to continue, click next.

Next

The circled area indicates the changes compared to the first instance of this screen.

Appendix J – Link Pointing Task (Cont.)

Phase Complete Version of Quality of Performance Screen

This Phase Complete

Please select the result of the task from the options below:

- ☐ I clicked the link quickly.
- ☐ I clicked the link.
- ☐ I clicked the link but had a little trouble.
- ☐ I moved before the beep but then I clicked the link.
- ☐ I think I clicked the link but my hand moved.
- ☐ I stopped or started accidentally.
- ☐ I forgot where the link was.
- ☐ Other (Please specify):

You have completed the tasks for this phase of the experiment. Next, you will be shown an animation of the new procedure for the next set of tasks.

When you are ready to continue, click next.

Next

The circled area indicates the changes compared to the first instance of this screen.

Appendix J – Link Pointing Task (Cont.)

All Tasks Complete Version of Quality of Performance Screen

Tasks Complete

Please select the result of the task from the options below:

- ☐ I clicked the link quickly
- ☐ I clicked the link
- ☐ I clicked the link but had a little trouble
- ☐ I moved before the link but then I clicked the link
- ☐ I think I clicked the link but may have missed
- ☐ I tapped or clicked accidentally
- ☐ I forgot where the link was
- ☐ Other (Please specify)

You have completed all the phases of the experiment. There are a few more questions and then you will be given a brief explanation of the data gathered for this experiment and asked for any final comments.

When you are ready to continue, click next.

Next

The circled area indicates the changes compared to the first instance of this screen.

Appendix K – Page Navigation Task

Page Navigation Task Animation Introduction Screen

Page Navigating Task

During this phase of the experiment, you are shown a link name. You will then select the link with a mouse.

Link

Read and remember the link name.

Click Next.

web link

Find the link and click it.

Move as fast as you can but
do NOT sacrifice accuracy.

This animation explains the process
of this phase of the experiment.

Play

Stop

Appendix K – Page Navigation Task (Cont.)

Page Navigation Task Animation Storyboard

Screen 1

Voice Over: For this set of tasks, the name of a link will be shown.

Screen 2

Action: Task description screen appears.

Screen 3

Voice Over: Once you have memorized the link name, press the next button.

Screen 4

Action: Subject clicks the 'next' button.

Screen 5

Voice Over: A web page will be shown.

Screen 6

Voice Over: Search for the link.

Screen 7

Voice Over: Click the link once you have found it.

Screen 8

Voice Over: You will then be asked for your evaluation of the result.

Appendix K – Page Navigation Task (Cont.)

Page Navigation Task Search Criteria Screen

Page Navigation Criteria

Memorize the link name below.

Link: **Organic Kamut Flour**

Use the mouse to click on the link when you have found it. The emphasis is on ACCURACY so do not try to click as fast as you possibly can.

When you are ready to start the task, click next.

Next

Appendix K – Page Navigation Task (Cont.)

Page Navigation Task Example Screen

Appendix K – Page Navigation Task (Cont.)

Page Navigation Task Quality of Performance Screen

Practice Results

Please select the result of the task from the options below.

- ☐ Found the link quickly.
- ☐ Found the link.
- ☐ Had trouble finding the link but found it eventually.
- ☐ I found the link but may have missed.
- ☐ I slipped or clicked accidentally.
- ☐ I didn't find the link and just clicked anywhere.
- ☐ I forgot the link name I was looking for.
- ☐ Other (Please specify)

If you are ready for another **practice session** click next.

Next

Appendix L – Visual Search Task

Visual Search Task Animation Introduction Screen

Visual Search Task

During this phase of the experiment, you are shown the name of a link. You will look for the link but you will not use the mouse. Instead, you will click the space bar when you find it.

Link

Read and remember the link.

Put both hands on the spacebar.

Click the spacebar. (The page will appear.)

web link

Look for the link.

Click the spacebar. (The page will blur.)

Grab the mouse.

Click where you saw the link.
Move as fast as you can but
do NOT sacrifice accuracy.

This animation explains the process of this phase of the experiment.

Play

Stop

Appendix L – Visual Search Task (Cont.)

Visual Search Task Animation Storyboard

Screen 1

Voice Over: For this set of tasks, the name of a link will be shown.

Screen 2

Action: Task description screen appears.

Screen 3

Voice Over: When you have finished memorizing the link name, put both hands on the space bar to prepare for the task.

Screen 4

Action: Subject moves hands to keyboard.

Screen 5

Voice Over: Press the space bar and the web page will be shown.

Screen 6

Action: User presses the space bar and a web page appears.

Screen 7

Voice Over: Search for the link.

Screen 8

Voice Over: Press the space bar once you have found the link.

Screen 9

Action: User presses the space bar.

Screen 10

Action: The web page blurs.

Screen 11

Voice Over: The text on the web page is blocked out. You will indicate where you saw the link on the web page by clicking in that location with the cursor.

Screen 12

Action: User grabs the mouse.

Screen 13

Action: User clicks on the link.

Screen 14

Voice Over: You will then be asked for your evaluation of the result.

Appendix L – Visual Search Task (Cont.)

Visual Search Task Search Criteria Screen

Visual Search Criteria

Memorize the link name below.

Link: Tidbits

Use the space bar to indicate when you have found the link.

Put both hands on the spacebar.

When you are ready to start the task, press the spacebar.

When this screen appeared a voice over announces, "Please put both hands on the spacebar for the next task".

Appendix L – Visual Search Task (Cont.)

Visual Search Task Example Screen

Appendix L – Visual Search Task (Cont.)

Visual Search Task Blurred Example Screen

When the user presses the space bar and the site is blurred a voice over announces, “Use the mouse to click in the location you saw the link.

Appendix L – Visual Search Task (Cont.)

Visual Search Task Quality of Performance Screen

Practice Results

Please select the result of the task from the options below.

- ☐ Found the link quickly.
- ☐ Found the link.
- ☐ Had trouble finding the link but found it eventually.
- ☐ I slipped or clicked accidentally.
- ☐ I didn't find the link and just clicked anywhere.
- ☐ I forgot the link name I was looking for.
- ☐ I found the link but then forgot where it was.
- ☐ Other (Please specify)

If you are ready for another **practice session** click next.

Next

Appendix M – Post Task

Design Changes Screen

Design Changes

What differences did you notice between the web sites?

	Different between sites	The same on all sites	Don't remember these details
Layout			
The position of the menus (e.g. top, bottom, left, right)	☐	☐	☐
The space between things on the page (e.g. wide, narrow)	☐	☐	☐
The colour used in the menu (e.g. yellow, red, green)	☐	☐	☐
Fonts			
The font styles (e.g. helvetica, times)	☐	☐	☐
The size of the type (e.g. 10 pt, 12pt, 14pt)	☐	☐	☐
The number of fonts used (e.g. 1, 2, 3)	☐	☐	☐
Images			
The quality of the images (e.g. good, average, bad)	☐	☐	☐
The number of images (e.g. 1, 2, 3)	☐	☐	☐
The size of the images (e.g. big, medium, small)	☐	☐	☐

When you are done click next to continue.

Next

Appendix M– Post Task (Cont.)

Prior Knowledge Screen

Prior Knowledge

Which statement best describes your knowledge of this experiment?

- ☐ I was not told anything except that it was about web surfing.
- ☐ I figured out that the spacing was being varied during the experiment.
- ☐ I knew before the experiment that it was about the spacing.

When you are done click next to continue.

Next

Appendix M– Post Task (Cont.)

Debriefing Screen

Debriefing

This experiment is specifically interested in the effects of spacing on web navigation behavior. The amount of white space, the blank area between content, was varied between web sites. The experimenter is interested in separating the visual task, *looking* around a web page, from the pointing task, *selecting* the link with your hand.

If any one you know will be participating in the experiment in the future, please do not inform them of the intent of the experiment as this may affect how they react to the web sites.

When you are done click next to continue.

Next

Appendix M– Post Task (Cont.)

Done Screen

Done

Thank you for participating.

Appendix N – Debriefing Script

[Done screen appears.] Well, thanks for your time. Do you have any questions about the experiment? [Wait for answer.] Here is your participation money and a contact sheet if you have any questions or comments. [Present \$10 and Post Experiment Contact Pamphlet Appendix O.] I need you to sign the receipt form that confirms you received your money. [Present Receipt Confirmation Appendix P.]

Appendix O – Post Test Contact Pamphlet

Internet Surfing Experiment

Thank you for your participation. Attached is your participation reward of \$10.

Research personnel.

The following people are involved in this research project and may be contacted at any time:

James Zdrek (Principal Investigator, 520-2600, ext. 6628);

Dr. G. Lindgaard (Faculty Sponsor, 520-2600, ext. 2255).

**Should you have any ethical or other concerns about this study then please contact
Dr. M. Gick, Chair, Carleton University Research Ethics Committee for Psychological Research,
520-2600, ext. 2664) or Dr. K. Matheson (Chair, Dept. of Psychology, 520-2600, ext. 2648).**

Appendix P – Receipt Confirmation Form

I, the undersigned, have received \$10 for participation in a "web surfing" experiment.

	Name (printed)	Signature	Date
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Appendix Q – Tables and ANOVAs for Task Differences

Table 8

One-Way Analysis of Variance Summary for Task Type

Source	df	SS	MS	F	p
Between Groups	2	1,151,380,838	575,690,419	69.711*	<.001
Within Groups	584	4,822,834,821	8,258,278		
Total	586	5,974,215,660			

Note. Levene's test for homogeneity was significant but both the Welch statistic and the Brown-Forsythe statistic were significant, so even though the assumption of equal variance is violated group differences can be assumed. * $p < .05$.

Table 9

One-Way Analysis of Variance Summary for Tasks Using Positive Click Evaluations Only

Source	df	SS	MS	F	p
Between Groups	2	717,987,945	358,993,972	139*	<.001
Within Groups	537	1,387,799,084	2,584,355		
Total	539	2,105,787,030			

Note. Levene's test for homogeneity was significant but both the Welch statistic and the Brown-Forsythe statistic were significant, so even though the assumption of equal variance is violated group differences can be assumed. * $p < .05$.

Appendix R – Tables and ANOVAs for White Space and Design Aptitude

Table 10

The Page Navigation Task's Means and Standard Deviations for White Space as a Function of Design Aptitude

White Space(pixels)	Designers		Non- Designers	
	N = 20		N = 18	
	M (ms)	SD (ms)	M (ms)	SD (ms)
0	4195	1575	5228	3154
4	4911	3377	3684	1481
12	4822	1974	3885	1742
28	5063	3084	3633	1501
60	4111	2605	4338	2008

Table 11

The Page Navigation Task's Analysis of Variance for White Space and Design Aptitude

Source	df	SS	MS	F		η^2
Between subjects						
Design Aptitude	1	10,323,748	10,323,748	1.214	.278	.033
Error 1	36	306,078,641	8,502,184			
Within subjects						
White Space	4	5,394,903	1,348,725	.275	.894	.008
Design Aptitude x White Space	4	42,239,610	10,559,902	2.153	.077	.056
Error 2	144	706,118,489	4,903,600			

* $p < .05$.

Appendix R – Tables and ANOVAs for White Space and Design Aptitude (Cont.)

Table 12

The Visual Search Task's Means and Standard Deviations for White Space as a Function of Design Aptitude

White Space(pixels)	Designers		Non- Designers	
	N = 18		N = 16	
	M (ms)	SD (ms)	M (ms)	SD (ms)
0	3333	1427	4505	4930
4	6520	9821	3500	1497
12	3743	2654	3233	1766
28	5288	4570	3245	1774
60	4542	2416	5585	5447

Table 13

The Visual Search Task's Analysis of Variance for White Space and Design Aptitude

Source	df	SS	MS	F	p	η^2
Between subjects						
Design Aptitude	1	19,101,094	19,101,094	.603	.443	.019
Error 1	32	1,013,371,336	31,667,854			
Within subjects						
White Space	4	63,708,478	15,927,119	.939	.444	.028
Design Aptitude x White Space	4	116,573,545	29,143,386	1.717	.150	.051
Error 2	128	2,172,019,720	16,968,904			

Note. Mauchly's test of sphericity was significant but using Greenhouse-Geisser to adjust the degrees of freedom did not find any significant results. * $p < .05$.

Appendix R – Tables and ANOVAs for White Space and Design Aptitude (Cont.)

Table 14

The Link Pointing Task's Means and Standard Deviations for White Space as a Function of Design Aptitude

White Space(pixels)	Designers N = 19		Non- Designers N = 20	
	M (ms)	SD (ms)	M (ms)	SD (ms)
0	1491	364	1490	406
4	1466	422	1505	377
12	1453	296	1547	417
28	1440	351	1505	399
60	1517	374	1501	415

Table 15

The Link Pointing Task's Analysis of Variance for White Space and Design Aptitude

Source	df	SS	MS	F	p	η^2
Between subjects						
Design Aptitude	1	64,154	64,154	.125	.726	.003
Error 1	37	18,978,040	512,920			
Within subjects						
White Space	4	30,039	7,509	.133	.970	.004
Design Aptitude x White Space	4	81,277	20,319	.359	.873	.010
Error 2	148	8,377,291	56,603			

*p < .05.

Appendix S – Baseline Measurement of Simple Reaction Time

Subjects

7 volunteers associated with the HOTlab were used as subjects.

Apparatus

The same application from experiment 1 was used to present the material.

Procedure

The experiment was presented on a series of screens available at the end of this appendix. The subjects were asked to make themselves comfortable and were informed of the experiment procedure, see Screen 1 and 2. The subjects were helped through the first three tasks by the experimenter.

For the page-navigation simple-reaction-time task, the subjects were asked to click the mouse when they saw a web page appear. The task was started by clicking the mouse, see screen 3. The screen changed to inform the subject that the task had started, see screen 4. A random delay of between 2.5 and 5 seconds occurred before the page was exposed, see screen 5. After the subject clicked the mouse, a screen was presented so that they had the option to indicate any slips or misses, see screen 6.

For the visual-search simple-reaction-time task, the subjects were asked to click the spacebar when they saw a web page appear. The task was started by clicking the spacebar, see screen 7. The screen changed to inform the subject that the task had started, see screen 8. A random delay of between 2.5 and 5 seconds occurred before the page was exposed, see screen 9. After the subject clicked the spacebar, the slips or misses screen was presented.

Appendix S – Baseline Measurement of Simple Reaction Time (Cont.)

Procedure (Cont.)

For the link-pointing simple-reaction-time task, the subjects were asked to click the mouse when they heard a beep. The task was started by clicking the mouse, see screen 10. The screen changed to inform the subject that the task had started, see screen 11. A random delay of between 2.5 and 5 seconds occurred before the beep was heard. After the subject clicked the spacebar, the “slips or misses” screen was presented.

The set of the three tasks were done in a random order. This was repeated 20 times. The first set was considered a practice session. After completing all the repetitions, the subjects were presented with two completion screens, see screen 12 and 13.

Appendix S – Baseline Measurement of Simple Reaction Time (Cont.)

Results

Excluding the practice sessions, 19 sessions were performed by 7 subjects. Of the 133 possible sessions, 3 sessions were excluded from the visual search analysis and 1 from the page navigation analysis. These exclusions were based on the self-reported errors gathered through Screen 6.

Table 16
The Simple Reaction Time Means of the Three Tasks

Task	Simple Reaction Time		
	N	M (ms)	SD (ms)
Page Navigation	132	391	87
Visual Search	130	299	87
Link Pointing	133	370	78

Discussion

These results show that there was very little difference in performance time between responding to visual (page navigation) or auditory (link pointing) stimulus with a mouse click, see Table 16. The change of input device from a mouse (page navigation) to a keyboard (visual search) reduced the reaction time by almost 100 milliseconds. This difference could be due to the types of muscle groups actuated when the arm is in a typist position as compared to a mouse pointing position.

The baseline measure is specific to the experimental apparatus. Generalizations or use of this data outside the scope of this experiment is not recommended.

Appendix S – Baseline Measurement of Simple Reaction Time (Cont.)

Screens

Screen 1. Welcome Screen

Screen 2. Experiment Procedure

Appendix S – Baseline Measurement of Simple Reaction Time (Cont.)

Screens

Screen 3. Page Navigation Simple Reaction Preparation

Screen 4. Page Navigation Simple Reaction Started

Appendix S – Baseline Measurement of Simple Reaction Time (Cont.)

Screens

Screen 5. Page Navigation Simple Reaction Exposure

Task Evaluation

Please select the check box if a slip or miss occurred.
Otherwise, click on the Next button

☐ Previous task was an error. (Please specify type of error below.)

Next

Screen 6. Slips or Misses Reporting

Appendix S – Baseline Measurement of Simple Reaction Time (Cont.)

Screens

Screen 7. Visual Search Simple Reaction Preparations

Screen 8. Visual Search Simple Reaction Start

Appendix S – Baseline Measurement of Simple Reaction Time (Cont.)

Screens

Screen 9. Visual Search Simple Reaction Exposure

Screen 10. Link Pointing Simple Reaction Preparation

Appendix S – Baseline Measurement of Simple Reaction Time (Cont.)

Screens

Screen 11. Link Pointing Simple Reaction Started

Screen 12. Debriefing

Appendix S – Baseline Measurement of Simple Reaction Time (Cont.)

Screens

Screen 13. Done