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A comparison of three-level menu navigation structures for web design

Jennifer Rose Kingsburg
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A COMPARISON OF THREE-LEVEL MENU NAVIGATION
STRUCTURES FOR WEB DESIGN

A Thesis

Presented to

The Faculty of the Graduate Program in Human Factors / Ergonomics
San Jose State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by

Jennifer Rose Kingsburg

May 2004

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ABSTRACT

A COMPARISON OF THREE-LEVEL MENU NAVIGATION STRUCTURES FOR WEB DESIGN

by Jennifer Rose Kingsburg

This thesis addresses the topic of three-level menu structures for web sites by measuring the performance and preference effects of different menu hierarchies. Two studies were conducted, each using 16 different participants. The first study compared left and top menu positions across three menu levels. The results indicated a benefit when the first (primary) menu level was located on the left side of the screen. In addition, performance was benefited by grouping second and third menu levels in the same plane, whether at the top or left side of the screen. The second study included a comparison of right-side menus. The results confirm the benefit of grouping the second and third menu levels in the same plane, and suggest the value of locating the primary menu level on the right side. Finally, users preferred primary menus that were located in the left or right plane rather than the top planes.

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I dedicate this paper to my father, one of the few people who knew what Human Factors was, and who supported my decision to pursue my education and career on the west coast.

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INTRODUCTION

Reliance on Web Sites

The Internet has become a useful tool to support many everyday tasks in both a personal and professional level. People refer to the web as a source of information; it is used daily to communicate with friends and co-workers and companies have taken advantage of the web to expand their business models. Within a three-year period (1997-2000), according to Nua Statistics (2000), the number of people who have access to the Internet has rapidly increased from 74 million to 407.1 million. In 2000, in North America alone, there were 167.12 million Internet users. In time this usage value will only increase as we continue into the 21st Century.

Even with the increase in the number of usability professionals working in the Web industry, and the numerous books and articles discussing web usability and design, it is still the case that the usability of many web sites is sub-optimal, with poor performance, and high error and drop-out rates (Nielsen, 1999). Nielsen (1998) estimated that 90% of commercial web sites have poor usability. He argued that the most aesthetically pleasing site, with many eye-catching graphics, more often than not has poor usability.

One of the problems that may lead to such poor usability in web site navigation design today is there are no clear, unified guidelines that discuss how to best configure multiple level menu structures for web sites. After looking at recommendations (or lack of) from web design books, and by evaluating what

designs are currently being implemented, no common design stands out as the most usable menu design approach to use in web development.

Since no guidelines exist there clearly is a need to determine if one menu structure is better than another and why. With the downfall of Internet companies from 2000 to 2001 (CNN.com, 2001), having an efficient navigation structure could be critical in today's market. A bad navigation structure may frustrate potential users and increase the likelihood that a web site's business will not exist a year after launching. In our observation of various web site usability tests it has been witnessed how quickly a user will navigate to a competitor's site, or look outside of the site they are using, when they cannot efficiently navigate and find information from the first site they have encountered.

It has become necessary, especially within e-commerce sites, to present at least three menu levels, if not more. No other study to date has tested the usability of more than two levels of menu navigation structures. Therefore, there is an obvious need to study the influence of various three-level menu designs on user performance and preference. Our interest lies in the most advantageous way to construct a three-level menu navigation structure in the context of a web site. It is our hope that this study will allow future web sites to be developed with a guided approach to the navigational structures for the best performing and most preferred layouts.

The Importance of Site Navigation

Users often become frustrated with a site when the navigation does not match their expectancies and schemas. Within 10 seconds a user will know whether or not they wish to continue navigating through a site or move onto the competition (Nielsen, 1996). Some sites have reported drop rates to be as high as 78% (www.bizrate.com, 2000).

How a site is structured clearly has a significant impact on its usability and ease of navigation. A study by Click-Here Commerce (www.infofarm.com, 1999) analyzed 50 commerce sites and determined that 32% of online stores lacked a clear global navigation structure (the overall layout structure used to navigate a web site). The question remains, "What is the best or most usable way to structure a three-level web site?" The answer is still unclear.

Literature Review of Previous Menu Navigation Research

Much of the past menu research has focused on breadth vs. depth of menus (Larson & Czerwinski, 1997; Kiger 1984; Miller, 1981); that is, how the menu should be ordered in terms of hierarchy (Card, 1982; Hornof and Kieras, 1999), and reading or searching within menus (Aaltonen, A., Hyrskari, A., and Raiha, K.J, 1998; Teitelbaum and Granda, 1983; Giroux & Belleau, 1986; Lee & MacGregor, 1985). Moreover, these studies were conducted in the context of software application menus rather than web site menus.

Recent research on primary menu structure provides a base on where to position the first level (primary menu) of a three-level menu structure. A recent

study by Bernard (2001) tested novice and expert web users' schemas for the locations of common web objects, including navigation. Participants included novice and expert web users. Each participant was seated in front of a computer monitor and asked to move the mouse to the location within a grid to the square(s) they expected to find the menu navigation, as well as other web site elements. For each element a cumulative total was calculated. Results of this study showed that both novices and experts expected to view navigation (menus) on the left side of the page, showing a preference and expectancy for the left side of the screen.

A study conducted by Gathman, Lee and Nader (1998) focused on primary menu locations performance and preference. This experiment looked at the effect of a web site's frame position for a constant menu bar. Their experiment looked to measure differences based on changing the location, or placement of the menu on the page. They hypothesized placing the menu along the top would result in the best navigation performance (fastest time). Their reasoning for a top menu as optimal was due to the common location of menus within software applications. Therefore, they felt this would cause users to have an expectancy for the menu location at the top of the screen. In addition, they believed the average distance from each link in the menu to that on the starting point (center of larger frame) would be shortened when positioned at the top rather than the bottom or sides of the page.

Twenty-four students from the University of Maryland participated, each with some level of web browsing and computer experience. Participants were presented with a web site with the frame located at the top, left, bottom or right side of the page. Each frame consisted of 10 links labeled sequentially in intervals of ten numbers. In the larger frame, users were commanded to "Click for a number" in which a random number would be presented and participants would have to select the number set within the smaller frame that corresponded to the number in the center of the screen.

To test for performance differences, time was measured from the onset of clicking for a number, to clicking the correct interval. Participants completed the same task five times for each of the four menu positions. A survey was administered at the end to gather participants' preference.

The average link click time was evaluated with top (2,993.75 ms) being the fastest over the left (3,200.76 ms), right (3,194.68 ms) and (bottom (3,295.05 ms). A single factor ANOVA was used to determine for differences in the true averages. All frames presented appeared to be equivalent based on the ANOVA. The median link click time was also evaluated. Again the top frame placement had the lowest median click time (2,680.00 ms), followed by the left (2,770.00 ms), right (2,910.00 ms) and bottom (2,940.00 ms).

When the average time was compared to the median link click time for each placement the top was again favored. The results of this study also show a larger difference between both values with the left frame compared to the right or

bottom frames. The survey showed preference for the left frame placement (41%) over the other three frame placements (29% top, 16% right, 13% bottom), but the overall performance favored the top frame placement. Yet, consistent with Bernard (2001), users stated a preference for the left side primary navigation frame. (One should note that this study only tested a single, primary level navigation.)

Backs (1987) compared horizontal and vertical menu formats based on position and size of menus. Eight McDonnell Douglas Corporation engineers, six male and two female, were used to test each of the vertical and horizontal menus. Each menu contained 4, 8, or 12 items. Participants were asked to locate a target item and report a numerical value located to the right of the item based on their selection.

A within-subjects design was used to balance the menu orientation with half of the participants receiving the horizontal menu first and half receiving the vertical menu. Results show the time to search for information was higher (slower) for larger menus (12 items) compared to smaller menus (4 items). The more significant finding relates to information retrieval. The vertical menu format proved to be faster than the horizontal menu for information retrieval.

Evidently, users' abilities, knowledge, and usage of web sites have to be taken into account when designing a menu structure. For example, one has to consider whether the majority of users are novices or experts in terms of their Web experience. Norman's 1986 study of menu preferences found that students

majoring in computer science preferred listing of commands in rows horizontally, rather than in columns, while non-computer science majors preferred a vertical (columns) listing. This finding may support presenting the primary and secondary menus on the top of the page (horizontal) for web-savvy users and on the side of the page (vertically) for novice web users.

Only a few studies have yet add some context and design in their test of the usability of menu design. A study by Bernard and Hambin (2003), compared cascading left and top menus with an “indexed” menu placed in the center of the screen. The left (vertical) and top (horizontal) menus relied on participants to mouse-over a desired menu to present the second level of links. Eighteen participants (8 male, 10 female) participated in this study, with the majority of participants both using a computer on a daily basis (89%) and using the web at least 25 hours a week (72.2%).

Participants were asked to purchase a number of items within the site. Tasks were written in such a way that the target link was implicit within the context of the task rather than being explicit to tell users to select a specific set of links. After completing a task set participants were surveyed for their preference between the three menu designs.

Results of this study show a faster task completion time for the Index menu design, which performed significantly faster over the vertical (left) or horizontal (top) menu designs. The horizontal menu layout was significantly perceived as the most distracting. No significance was found for “perceived ease

of navigation,” “perceived frustration,” or “link arrangement preference.” Although not significant, the vertical menu was both faster and more preferred over the horizontal menu design.

The most recent study to date to determine the usability of menu location was conducted in Germany by Kalbach and Bosenick (2003). Their usability study of the Audi automobile web site aimed to determine the difference in performance and preference between left- and right-justified menus. Two web sites, each with the same content, were created for the Audi automobile company. One site placed the menu navigation on the left side and the other placed the menu navigation on the right side. The hypothesis for this study assumed that the left-justified menu would perform better over the right-justified menu, but in the end there would be no significant differences between the two menu layouts. Additionally, they believed the right menu would initially perform slower, yet would operate as well as the left-justified menu.

An independent usability consulting company was selected to conduct the usability test in Germany. A total of 64 participants, ranging in age from 20 to 60 years old, took part in the study. Of these participants, 18 participants (28%) used the Internet for less than a year, 36 participants (56%) used the Internet for one to three years, and 10 participants (16%) used the Internet for three or more years. Students, unemployed, those individuals working in the automobile, press and media or internet industries were excluded from participating in this study.

Participants interacted with a prototype consisting of 10 clickable pages, constructed of screen shots for each page and one “under construction” page. Two experimenters conducted the study, one guided participants through the tasks and the other recorded data in a separate room. Time to complete tasks was collected using a stopwatch. Any time greater than 180 seconds was deemed a “break-off” by the experimenter. Tasks consisted of finding the company’s address, looking up information related to the company and looking up information related to a specific car.

Results of this study show no significant differences between left and right menu designs. Additionally, within an individual task no significant differences occurred. Experimenters noted that participants worked slower and spent more time scanning the menu content on the screen with the right menu navigation compared to the left menu navigation. Based on results of this study the authors conclude one may use a right side menu navigation since there was little difference compared a left side menu navigation position. However, when using the right menu design, users may initially have slower times given the unconventional design.

Although this study was one of the first studies to examine the usability of the right menu navigation, there are a number of limitations with this study. First, the study was a between subjects design. Participants did not interact with both menu navigation schemes. Second, the study only compared left and right menu navigation positions, and did not examine use of top menu navigation. Finally,

this study was conducted in Germany therefore the results cannot be generalized across all cultures.

In summary, the aforementioned studies show that while users perform better when the primary (first level) menu is positioned at the top of the page, users consistently prefer a primary menu to be positioned on the left side of the page. This type of performance-preference dissociation is not uncommon (Andre & Wickens, 1995). The present study first aims to compare these two primary (1st level) menu positions in the context of a three-level menu structure. Additionally, previous research has shown a right-justified menu design to have equal performance with that of a left-justified menu. The present study will also address the question of how a primary right menu structure performs and is preferred to primary left and top menu structures.

A Survey of Web Site Menu Structures

One consideration in designing a three-level menu structure is to determine the placement of each level, as well as determine how any given level relates to the next as a whole, in designing a three-level menu structure. A number of questions need to be addressed: Should the primary menu be placed on the left, top, or right portion of the page? Should all levels be grouped together or should at least one level be split across two planes? Finally, if there is a split across two planes, should the primary and secondary menus, or the secondary and tertiary menus, be grouped together on the same plane?

Since little or no literature exists suggesting how a three-level menu should be structured, we conducted an initial survey of 69 web sites that incorporate multi-level menu structures to determine the most commonly used menu locations. Sites were broken into two categories: corporate and e-commerce sites (N=57) vs. human factors, usability, and design firm web sites (N=12). In the former category, web sites were chosen among popular companies at the time. In the latter category, web sites were randomly selected from known consulting companies listed by Usability Professionals' Association (UPA), Bay Area Special Interests group of Computer-Human Interaction (BAYCHI), and the Human Factors and Ergonomics Society (HFES) directories, as well as others found via web searches and usability Meta sites. The Human Factors web sites were analyzed to see if there was a consistent method for a three-level menu navigation structure on a professional level.

The focus of this analysis was on the final positioning of the each level in the navigational layout for each web site. (Note that some sites present their primary menu on the top, but when navigating two or three levels deep within the web site, the menu location switches to the left or right side depending on the navigational structure used.)

As previously stated, performance and preference data has shown a benefit for the top and left side primary menu placement, respectively (Bernard, 2001; Gathman, Lee & Nader, 1998). Based on this evidence, the sites surveyed were placed into one of nine categories (see Table 1 and Appendix A). The first

eight categories are a cross-factor of placement of menus on the top or left side for each of the three levels. The ninth category, “other”, was added for sites that used a structure that did not fit into one of the other eight factorial structures.

Of the sites in the commerce site category, 56% used the Top-Left-Left (TLL) structure. In other words, the first menu level was presented at the top of the page, the second level menu appeared on the left side of the page, and the third level menu also appeared on the left side of the page. The next most common structures were the LLL (16%) and TTT (9%) structures. Of the human factors professional sites, 25% used a menu structure other than the eight top and left combinations. In each of these sites, at least one of the menus was placed on the bottom or right side of the page.

Looking at the current menu structure across both categories of web sites (see Figure 1), we see that the two most common designs for the primary, or 1st-level menu is to present this menu horizontally across the top portion of the page (67%) or as a side menu, vertically down the left side of the page (22%). This finding is consistent with previous research showing performance and preference benefits (Bernard, 2001; Gathman, Lee & Nader, 1998). When the primary navigation is presented at the top of the screen 76% of the sites surveyed then placed the secondary and tertiary menus on the left side (TLL). When the primary navigation is presented on the left side of the screen 67% of the sites surveyed placed the secondary and tertiary menus on the left side (LLL).

Table 1

Top and Left Three-Level Menu Structures

Code	Graphical Representation	Code	Graphical Representation
Top-Top-Top (TTT)		Left-Left-Left (LLL)
Top-Left-Left (TLL)		Left-Top-Top (LTT)
Top-Top-Left (TTL)		Left-Left-Top (LLT)
Top-Left-Top (TLT)		Left-Top-Left (LTL)

Across both categories of sites (see Figure 2), 51% used the TLL menu structure, followed by the LLL (15%) and TTT (7%) structures. Further, most sites (79%) favor grouping the second and third level menus in the same visual plane (either LL or TT). It should be noted that 12% of sites surveyed used an alternative organization, typically placing menus on the right or bottom of the screen.

Figure 1. Percentage of menu structures surveyed for e-commerce and human factors sites.

Figure 2. Combined percentage of menu structures surveyed.

Implications of Usage Data

According to Nielsen (1999), if 90% of the large sites use a common method of doing something in a single manner then this becomes a standard design in which all web sites should comply. Nielsen comments that one can deviate from the standard if the alternative design has 100% higher measured usability. If only 60% of the large sites do things in a single manner then it strongly favors a single method and a site should not comply unless there is 50% higher measured usability. When less than 60% use a single method then Nielsen gives the developer the freedom to use an alternative design, but adds that when at least 20% of the big sites are going in one direction one should choose the well-known design unless the alternative can reach 25% higher measured usability over the best designs used by the large sites.

To understand Nielsen's perspective, recall that it is common for users to encounter a variety of sites on a daily basis while surfing the web at work or at home. If the majority of sites are using a common design for the menu structure of their web site, users will come to develop expectancies when accessing a new site for the first time. Users will have preconceived ideas on how the structure should work based on the location of items. Bernard's study (2001) showed we have an expectancy for menus or navigation to be located on the left side of the screen.

As shown by our analysis, no single menu navigation scheme is used by 90% of web sites. Part of this is due to the fact that each web site focuses on a

different set of users, each site is geared toward different applications and often company goals and ideologies tend to outweigh common usability standards. Nielsen (1999) stated that a web site should only go against the norm when it shows a higher measured usability over a given percentage compared to larger sites. Yet, previous studies have yet to test the measured usability of menu navigation schemes. Only after confirming which navigational structure shows greater usability over the others and it has been implemented to allow for user's expectations can that navigation scheme be considered the standard.

Justification for Common Menu Structures

Norman (1991) discussed when users are focused down a path they must comprehend the act of navigating through menus rather than the overall clustering of items. He posited that a good design would visually walk a user through a site with little frustration and high ease of navigation. A web site's "visual scope" can determine how users navigate the site. Norman, Welden and Shneiderman (1986) defined visual scope as, "the degree to which the user is able to integrate information across a display of multiple windows or screens and to grasp the whole of whatever is being displayed." Although originally applied to multiple windows on a computer desktop, this concept can be carried over to navigation of web sites. We propose that each level of a three-level menu structure on a web site can be considered three separate pages, layered one on top of the other. If users have a good understanding of how each level relates to

the next and how the menus relate as a whole then the menu structure will have a better likelihood to match the users visual scope.

From our survey of web site structures, most commercial sites favor what we term the TLL menu structure. Figure 3 shows two real-world examples of the TLL menu structure. This structure groups the secondary and tertiary menus together on the left with the primary menu at the top of the page. A logical argument in support of this structure stems from the fact that when first looking at a document or web site we focus our attention toward the top of the page (Wickens, 1999). According to Flemming (1998) we approach a screen in the same manner as we read. As such, items placed at the left and top of center are considered more important and typically noticed first. It would then benefit a site to use a horizontal primary navigation layout. After all, in America we read from left to right. Further, we are accustomed to viewing a table of contents vertically down the page. Knowing how a large web-user population reads and how information is typical presented in other contexts, it is logical that users might benefit from placing the secondary and tertiary menus vertically along the left side of the page.

The TLL structure groups the secondary and tertiary menus together on the same plane separate from the primary menu. Often, based on the hierarchy of information, the secondary and tertiary menus may relate more to one another than that of the primary and secondary menu. According to the proximity

Figure 3. Examples of the Top-Left-Left (TLL) menu structure. Note that the primary menu is placed across the top of the page, while the secondary and tertiary menus are placed vertically along the left side of the page.

compatibility principle (Wickens & Carswell, 1995; Wickens & Andre, 1990) those items that relate to one another from an information perspective should be placed spatially in close proximity to one another as long as they do not create clutter. When two menu sets are grouped together on the same plane one can better process and compare the menus since they are in the same proximity as opposed to when split across two different planes.

Taking the work of Backs (1987) into consideration, presenting a list of menu items vertically down the page resulted in faster retrieval of information compared to when placed horizontally across the page at the top. Placing two menus on the same plane vertically down the page therefore may result in faster retrieval of information compared to when one menu is placed horizontally across the screen with the other menu placed in another plane requiring users to move one's attention vertically down the page. This grouping may also reduce the attentional demand required of users to navigate through menus when at least two menus are vertically down the page in a single plane.

Fitt's Law (Fitts, 1954; Fitts & Peterson, 1964) can also be used to describe the benefits for the TLL menu structure. When navigating through a web site often the majority of one's navigation occurs past the first level, therefore users will focus more attention to the content placed within secondary levels and beyond. When navigating to different links within a secondary or between the secondary and tertiary menu levels, shorter cursor movements are necessary compared to jumping from the side to the top of the page. Fitt's Law also tells us

that shorter mouse movements are better, lending another reason for grouping at least two menu levels on the same plane.

The second most popular menu structure found from our analysis was the LLL method, with all levels presented on the left plane (see Figure 4). Sites that present primary menu navigation on the left typically also present deeper level menus on the left side rather across the top of the page. This structure has benefits from both an information retrieval, as well as screen real estate design, perspective. As explained for the TLL menu structure, a menu placed vertically down the page will allow users to retrieve information faster than when displayed across the page (Backs, 1987).

From a screen real estate perspective, grouping all levels on the left side of the page allows for more growth down the page compared to other menu structures that split across the screen or use only the top portion of the screen to present menus. This design allows for more real estate to be devoted toward content, but with a tradeoff of a large set of links that may force users to scroll down or across a large menu set. Another benefit of this design is users will only have to attend to a single side of the screen, which may leave users to perceive the web site to appear less cluttered.

Just as with the TLL menu structure, the work of Backs (1987) has an influence on one's ability to retrieve information faster with all content vertically down the page with the LLL menu structure. However, there could be some drawbacks since the screen may appear too cluttered with too many links on

Figure 4. Examples of the Left-Left-Left (LLL) menu structure. Note that the primary, secondary and tertiary menus are all placed vertically along the left side of the page.

one side of the screen, making it more difficult to process compared to a single or double menu set.

Additionally, the proximity compatibility principle and Fitt's Law play a roll in the design and processing of information with this menu scheme. All three levels are grouped together, therefore there is no confusion as to where to move the cursor to make a selection from the menu structure. Placing all menus on the same plane requires less cursor movement to navigate with a menu level and between menu levels since all content is displayed in a single plane.

Finally, one design method that is not often found among commercial web sites, but which might prove to be an effective design is the LTT layout (see Figure 5). This is a reversal of menu placement from the TLL, where the primary menu is presented on a different plane from the secondary and tertiary menus. . The same principles of proximity compatibility, faster information retrieval vertically down the page and better use of screen real estate hold true for the LTT menu structure as well.

Grouping the secondary and tertiary menus at the top with the primary menu on the left has been termed the "Chessboard layout pattern" by uidesign.net (1999). They hypothesize this layout is best used when restricted to three layers and is most useful for the novice user where choice actions are presented within the horizontal menu at the top. The authors stated the goal of this structure, as well as a good page layout, is to navigate to any other section

within two mouse clicks or links. This layout allows for the vertical search of main menu items along the left side, which should be faster than if presented horizontally at the top of the page.

The grouping of secondary and tertiary levels on the same plane, a exhibited by LTT or TLL, might present a more comfortable visual scan compared to a structure that forces users to jump back and forth in different directions on a different plane, such as a TLT or LTL menu structures.

In observations of numerous web site usability tests, the grouping of the secondary and tertiary menus together at the top of the page has been found to be an efficient and aesthetically pleasing design technique (A. Andre, 2001, personal communication). Additionally, as shown in our analysis, 50% of sites surveyed used a structure that split the primary level from the secondary and tertiary levels.

This study will examine whether a vertical or horizontal orientation of menus and the grouping of menu levels (all together on a single plane vs. split across multiple planes) provides the faster and accurate method to navigate the menu hierarchy.

Right-Hand Menus

The right side of a page has most recently been used to place secondary links or present an additional menu set that does not relate to the main menu set. It is becoming more of a standard to incorporate the right side to display more information or links, however no site has yet to incorporate a primary right-hand

menu scheme. Use of the right side vertically down the page may have some of the same benefits as the left side. However, users do not have the same expectancy for using the right side as a means for navigating through a site.

Nielsen (1999) argued for the use of what he calls a “right justified navigation rail”. He believes that we are first drawn to look at the content of a page. In the United States, we read from left to right. Once we are done looking at the content we focus our gaze toward the right to pick up cues as where to proceed next. Nielsen suggests placing the menu on the left would allow users to skip over menus before scanning the content of the page.

Nielsen’s second reasoning for using the right side comes from Fitt’s Law (Fitt, 1954). We know shorter mouse movements are best therefore the target should be placed as close to the starting position as possible. Assuming a site that requires users to scroll pages, Nielsen believes placing the navigation next to the scroll bar will save users time and is a better alternative than forcing users to switch from one side of the page to the other.

Bailey, Koyani, and Nall (2000), in evaluating the usability of health information web sites with the National Cancer Institute, found users will click on topics located in the right margin more efficiently compared to topics placed on the left since they are located closer to the scroll bar. Moving the cursor between the scroll bar and index item can therefore be accomplished faster. However, they claim that this design would best benefit users navigating a web site on a laptop.

Kalbach and Bosenick (2003) compared placement of left and right menus in the design of a web site, finding no significant differences in performance between left or right menus. Yet, they recommend use of right-justified menus, stating that although users may be slow to use a right menu at first, they are quick to adjust and can use a right-justified menu just as efficiently as a left-justified menu.

This study will attempt to determine whether use of the right-hand side for a primary menu increases successful navigation within a three-level menu structure, as well as whether or not there is a preference to start on the right compared to the left or top.

Summary

No single menu navigation structure has become the standard in web development. After conducting a survey of commerce and usability web sites we found the most common three-level menu schemes use top and left menus, with the TLL structure outnumbering all other menu schemes (see Figure 1 and Figure 2). Previous research has shown better performance and preference for horizontal top and vertical left side menus schemes, respectively (reading from left to right and searching faster with a vertical menu structure). In contrast, Nielsen argues for a right menu structure to be considered over the left. As well, Kalbach and Bosenick show similarities in performance between left and right menu placement.

Though logical arguments have been made, no study to date has tested the usability and performance of multiple menu level structures under a specific task regimen. Our study aimed to determine the menu navigation structure that demonstrates the best navigation performance and yields the highest user preference ratings.

The Present Study

This study will determine the optimal three-level menu structure(s) for the design of a web site. The focus here is on menu structure, not the aesthetic design of the site. Holding the design constant this study hopes to determine the optimal three-level menu structure. For the purposes of this study an optimal menu structure is defined as one where the majority of users will perform the most accurate selections, have the least number of unnecessary clicks, the fastest task completion time, and viewed as the most preferred. In doing so, we ask: 1) Should the primary menu be placed on the top, left or right side?, and 2) Should first and second levels be grouped together or separated?

Based on the literature, human factors principles, our analysis of common web site structures, and experience in evaluating web sites we do not have a clear hypothesis regarding the ideal location of the primary menu (left versus top versus right). We do however hypothesize that the most advantageous menu structure is determined by whether or not the destination pages (third level items) are grouped with the secondary (navigation) menu.

The specific hypothesis, therefore, is that the best menu layout is afforded when secondary and tertiary menus are grouped together, but separate from the primary menu, as presented in the TLL, LTT and RTT layouts. In the end, it is the grouping of secondary and tertiary menus that will be a more important factor than the position of the primary menu. We believe this grouping will prove better over other structures due to what we know about cursor movements (Fitt's Law), use of screen real estate, the proximity compatibility principle, the visual scope and relationship of pages, visual organization, and relationship of links on the screen as previously discussed above.

This study proposes to address the hypotheses through two experiments. The study was split into two parts due to the fact that factoring all conditions (top, left or right) would create too many conditions for a within-subject design. In addition, there was a concern for fatigue for a participant to interact with as many as sixteen different menu structures in a single session. Another reason was since many web sites do not place their menus on the right side, the uniqueness of the right side menu was better studied alone, separate from the left and top combinations.

The focus of the first experiment was to compare factorial combinations of vertical/left and horizontal/top layouts of three menu levels. The second study then compared the four most preferred menu layout conditions from Experiment 1 against a set of menu layouts that place the primary menu on the right side of the screen (c.f., Nielsen, 1999). The menu structure deemed most

advantageous is one where tasks are completed in the fastest time, links are accurately selected in order, and participants have a preference for a given menu structure that is the least frustrating and confusing, and perceived as most usable.

EXPERIMENT 1: METHOD

Experimental Design

A 2 x 2 x 2 factorial within-subjects design was used, resulting in eight menu structure navigation conditions, as shown in Table 2. The three factors of this design are the location of the primary, secondary and tertiary menu levels. For this study, each level represents a factor of position, placed either on the left plane (left side) or top plane (top portion) of a web site page.

The presentation order of the eight menu structure navigation conditions was counterbalanced across participants (see Appendix B). A random order was pre-selected to determine the order for the menu structures. Each participant interacted with each of the eight menu structures in a different order. The condition order for each participant, referred to as a Latin Square counterbalance, after the first participant was determined by “snaking” the order of web sites based on the order of the first participant. See Appendix B for a table of participant web site interaction order.

These conditions allowed us to compare the vertical/left and horizontal/top menu placement for each of the three menu levels. In addition, by comparing conditions 3 and 7 (secondary and tertiary menus grouped together) against conditions 2 and 6 (secondary and tertiary menus on separate axes), we were able to examine the effects of grouping the secondary and tertiary menus together. Likewise, by comparing conditions 1, 2, 5 and 6 (primary and secondary menus grouped together) against conditions 3, 4, 7 and 8 (primary

and secondary menus on separate axes), we were able to examine the effects of grouping the primary and secondary menus together.

Table 2

2 x 2 x 2 Factorial Menu Structure Conditions used in Experiment 1

Condition #	Menu Layout (primary-secondary-tertiary)
1	LLL
2	LLT
3	LTT
4	LTL
5	TTT
6	TTL
7	TLL
8	TLT

Participants

Sixteen undergraduate psychology students were given 2 hours of course credit to participate in this study. All participants were experienced web users, with a wide range of web site usage (self-reported). All participants had purchased an item online within six months prior to taking part in this study. To determine the level of web expertise participants were screened for their web experience using the screener found in Appendix C.

Approval for use of human subjects was received from the San Jose State Internal Review Board (IRB). A copy of the letter of approval for use of human subjects for this study can be found in Appendix D.

Apparatus

All participants interacted with a computer workstation consisting of a Pentium III PC and a 17-inch monitor. The fictitious web sites were run off of local files, through MS Internet Explorer, v 5.0.

Stimuli

Each navigational condition was created using Adobe PageMill (see Appendix E for the three levels of menu categories for each navigation scheme). Each navigation condition was exemplified by a different fictitious store (e.g., toys, books, clothing, and sports). Category names within each store type were selected by examining common categories used within other web sites, such as Yahoo Shopping and Amazon.com. The first menu level represented the main categories of items offered by the fictitious store in addition to other high level links (clients, about us, contact us). See Figure 6 for an example. The second level presented the subcategory of offerings under each of the main category headings (see Figure 7). Finally, once participants reached the third level (see Figure 8), participants were presented with approximately 1.5-inch thumbnail images of six different products, accompanied by a description of the product, presented in the center portion of the page. Selecting a thumbnail image then displayed a final confirmation screen, congratulating participants on completing

the task, and providing a note to the participant to continue onto the next task (see Figure 9).

Figure 6. Screen shot of the primary (first) level menu for the LLL navigational scheme.

Figure 7. Screen shot of the secondary (second) level menu for the LLL navigational scheme.

Figure 8. Screen shot of the tertiary (third) level menu for the LLL navigational scheme.

Figure 9. Screen shot of the confirmation page of the LLL navigational scheme.

Category names were evenly distributed across or down the page in a frame. Those navigation conditions with a menu on the left side were blocked off with a vertical line down the page to separate the menu from page content. Likewise, those navigation conditions composed of a top menu were sectioned off with a horizontal line across the page. See Figures 6 through 9 for an example of each of the three navigation levels and final confirmation screen.

Tasks

Participants were instructed to perform a number of tasks by locating various items to be purchased. Some tasks started at the secondary level or sub-category level, while most tasks started at the primary level. All tasks ended at the tertiary level with the presentation of a final confirmation page verifying the

item selected. Each task was written in such a way as to not present the exact menu order. For example, instead of asking participants to purchase a “women’s short sleeve shirt,” participants were asked to purchase “a short sleeve shirt for a woman.”

A sample set of protocol tasks for the LLL condition is shown in Table 3. Included in this table is the fastest, most accurate correct path that participants could take to complete each task, as well as the different menu level(s) encountered for each task, with “1” representing the primary menu level, “2” for the secondary menu level, and “3” as the tertiary menu level.

Dependent Measures

The following performance and preference dependent measures were used to determine an overall score for each condition.

Navigation time. The total time to complete each task for each condition was recorded. Navigation time was measured using the Ergobrowser™ (Ergosoft Laboratories, <http://www.ergolabs.com>) timing software. This software ran as a background web browser and recording each click and the time between clicks as the participant navigated through each fictitious web site.

Selection errors. The number of excessive clicks, known as selection errors, was documented for each participant’s interaction of each menu structure, for each task, by the experimenter. The number of selection errors associated with each condition was then calculated based on the difference of actual clicks from the minimum number of clicks required to complete a task.

Table 3

Sample Task Protocol for Condition LLL (Computers)

Task	Correct Path: Fastest, Least Number of Clicks	Menu Level(s)
Purchase the Halfway brand Ergonomic Keyboard from the Peripherals section.	Peripherals>Keyboards>Ergonomic	1, 2,3
Purchase the drawing software program Pro Draw3	Software>Graphics & Drawing>Drawing	1, 2,3
Purchase the B1200 Compaq desktop PC.	PCs>Desktop>Compaq	1,2,3
Purchase the Sony 1600 notebook PC.	Notebooks>Sony	2,3
Purchase the Apple 920Xi notebook PC.	Apple	3
Purchase the Hitachi DVD drive from the Peripherals section.	Peripherals>Drives>DVD	1,2,3
Purchase a Canon 6300 scanner.	Printers&Scanners>Scanners>Canon	1,2,3
Purchase a Canon L550X inkjet printer.	Inkjet Printer>Canon	2,3
Purchase a Lexmark L2300 inkjet printer.	Lexmark	3
Purchase the 626 model 19" IBM monitor.	Monitors>IBM>19"	1,2,3
Purchase the 666 model 15" NEC monitor.	NEC>15"	2,3
Purchase the 197 model 19" NEC monitor.	19"	3

Cursor movement. The frequency of cursor movements to a plane other than the correct plane for a task was recorded for each participant, for each task, in each condition. By recording the number of times participants move their cursor to a different plane we looked for patterns of incorrect cursor movement between menu structures and different groupings of menu levels. An incorrect cursor movement was also recorded, for those conditions where at least two menus were grouped on the same plane, when participants hovered over the wrong menu or a location of the page that did not contain a menu.

Hesitation. The frequency of hesitation exhibited by participants to move their cursor from one menu level to another was documented as a hesitation error. As with cursor movement, we looked for patterns of hesitation associated with different groupings of menu levels. Hesitation was defined as any obvious moment to the observer where the participant was slow to respond, where the participant was thinking about where to go next or appeared confused and slow to select the next link. Hesitation could occur at the onset of a task or at any time navigating between menu levels.

Overall preference. At the completion of each section participants completed a survey which included ratings and rankings of the following performance, preference and other usability dimensions. Participants were asked to rank the eight conditions from 1, best to 8, worst for the following:

- ❑ Fastest to complete tasks
- ❑ Easiest to navigate between links
- ❑ Easiest to navigate accurately with fewest errors
- ❑ Most intuitive
- ❑ Overall preference

The main focus was on the overall preference of menu structures and the difference in ratings between different groupings of menu levels. A copy of the survey is shown in Appendices F and N.

Measurement integration. In some cases, one dependent measure correlates with another. For example, less hesitation correlates with a faster reaction time. A web site that a participant finds easy to use will often be the one where selection is fast and accurate and errors are minimal. However, some dependent measures may not correlate. A participant may execute the correct order of steps in a fast time, but show considerable hesitation with their mouse movement. Subjectively, participants may rate a web site as very easy to use when in fact they had a high number of errors.

To evaluate each menu structure an overall score was equated using all performance and preference data. Equal weight for each measure was cumulated to produce a final overall score for each structure. This allowed us to compare each menu structure taking all dependent measures into account.

Additionally, but not as important, each dependent measure was given an overall adjusted weighted score based on what we believe to be the critical

factors influencing menu navigation. For this study, the ranking of dependent measures from most important to least are: subjective measure, cursor movement, navigation time, hesitation, and selection errors (See Table 4). Our primary focus was cursor movement and one's subjective rating. Our secondary focus was on overall navigation time and hesitation and our tertiary focus on selection errors. This adjusted weighting was used to determine if one or more of the dependent measures impact the overall performance and preference of the menu structures final outcome. However, note that the equal weighting is used for the primary analysis in comparing the eight menu structures. Findings for adjusted weight scores and comparison to equal weight scores can be found in Appendix G.

The overall adjusted weight score was compared to the overall score that uses an equal weighing for each measure to determine if there are differences in results based on menu levels across all measures. (See Appendix H for the comparison of adjusted and equal weights).

Table 4

Equal and Adjusted Weight Overall Score Distribution

Dependent Measure	Measurement	Equal Weight	Adjusted Weight
Overall Preference	Number	20%	X10 (25.64%)
Cursor Movement	Frequency	20%	X10 (25.64%)
Navigation Time	Seconds	20%	X7 (17.95%)
Hesitation	Frequency	20%	X7 (17.95%)
Selection errors	Number	20%	X5 (12.82%)

Procedure

Each participant was greeted by the experimenter and brought to the lab where they filled out a consent form (See Appendix I). After completion of the consent form participants were introduced to the computer workstation, making any necessary adjustments to the computer workstation or chair and clarifying any concerns and provided initial instructions (See Appendix J for experimenter instructions).

A training session, composed of five web-shopping tasks was first conducted to allow participants to become acquainted with using the

Ergobrowser™ software to start and stop their navigation time for each task. Training tasks were drawn from the Yahoo Shopping web site and did not involve any of the experimental sites.

Next, participants were asked to complete a set of 12 navigation tasks (see Table 3 and Appendix K) for each of the eight fictitious site navigation conditions. The presentation order of the eight site navigation conditions was counterbalanced across participants and within each session (See Appendix B for a chart of participant interaction order). Participants interacted with each of the eight web site conditions, completing six tasks for each condition. After each task set for a single condition the cache history was cleared from the web browser and the web site reloaded. Participants then completed the second set of tasks in the reverse order, starting with the last condition experienced in the first set, working their way back to the initial web menu structure from the first set of tasks. Refer to Table 5 for an example representation of the menu structure order over the course of a given participant's trial.

Participants interacted with each site navigation condition on their own without providing a verbal protocol to the experimenter. Participants were asked to read each task first silently, then out loud before they could begin. An example of a navigation task is *"Purchase the Halfway brand Ergonomic keyboard from the Peripherals section"*. Tasks were explicit in providing the names of links to select from the menu, but were not presented in the exact order as it relates to the hierarchy of menu categories. Each participant was advised to behave as if

Table 5

Menu Structure Interaction Order Over Time

Interaction Order	Menu Scheme
1	A
2	B
3	C
4	D
5	E
6	F
7	G
8	H
9	H
10	G
11	F
12	E
13	D
14	C
15	B
16	A

they would if they were in their home or office setting, shopping for items for themselves, or as gifts for friends and family and to select as fast and accurately as possible.

Participants clicked on the “Start Task” button before starting their navigation task, which initiated the background timing for a given task. Once participants had reached the final confirmation page for a given task they clicked

on the “Task track” button in the upper right-hand corner, which stopped the timing for the given task. The same procedure was used for the remaining set of tasks. After each set of tasks for a given web site condition was completed the experimenter entered the lab to set up the computer for the next condition by selecting the next set of files and pointing the Ergobrowser™ program to the correct file for that condition.

Following the completion of the second set of tasks, participants were asked to review each menu design and navigate each of the eight web site conditions in a free-form manner for a period of approximately one minute per structure. The experimenter kept track of the time for each web site, indicating to the participant when it was time to move onto the next web site condition.

Next, participants completed the post interaction usability survey aimed at assessing their subjective rating of navigation usability. The first part of the survey required participants to draw out the menu structure they felt overall demonstrated the most usable layout. In addition, a final, comparative survey was completed, requiring participants to rank their preference among the eight menus conditions based on different criteria, and to collect additional subjective usability and preference data. See Appendix F to view the final survey. Finally, the experimenter debriefed participants as to the purposes of the study and answered any questions each participant may have regarding the study. Similar, but different tasks were performed for each of the additional seven site navigation conditions.

EXPERIMENT 1: RESULTS

Based on data from video analysis, tracking software, and final surveys, a statistical analysis for both performance and preference data was conducted to determine the level of significance of results. Navigation time, selection errors, hesitation, cursor movements, and overall preference for each participant were analyzed using an individual repeated measures analysis of variance (ANOVA). For each measure the mean value, standard deviation, rank (1, best to 8, worst), and graphical representation of values are presented below. When possible an analysis of any significant correlations was conducted. Level of significance for this study was defined to be $\alpha \leq 0.05$.

A secondary analysis was conducted for independent measures using a single factor ANOVA, with eight levels, to determine the difference in significance between the different menu structures.

Finally, selected contrast ANOVAs were conducted to determine any differences between menu structures with similar groupings from all other menu structures. This resulted in four additional analyses: 1) the four structures with a primary left menu (LLL, LLT, LTT, LTL) were collectively compared against the four structures with a primary top menu (TTT, TTL, TLL, TLT), 2) the four three-level menu structures which group the primary and secondary menu levels on the same plane (LLL, LLT, TTT, TTL) were collectively compared against all other menu structures (LTT, LTL, TLL, TLT), 3) those menu structures that grouped the secondary and tertiary menu structures (LLL, LTT, TTT, TLL) were collectively

compared against all other menu structures (LLT, TTL, LTL, TLT), and 4) within those menu structures that group the secondary and tertiary menu levels together, a comparison between those menu structures that group all menu levels on the same plane (LLL, TTT) was compared to those that split secondary and tertiary menus from the primary menu on a different plane (LTT, TLL).

Navigation Time

The mean values, standard deviations and ranking (1,best and 8, worst) for navigation time are displayed in Table 6. There was a main effect for navigation time for the primary menu level, $F(1, 15) = 11.119$, $p \leq 0.05$, Eta-Squared = 0.426. As shown in Figure 10, performance was faster when using a web site whose primary menu was located on the left side of the page (LLL, LLT, LTT, LTL) than those with a primary menu located on the top side of the page (TTT, TTL, TLL, TLT).

There was also a main effect of navigation time for the secondary menu level, $F(1, 15) = 14.079$, $p \leq 0.05$, Eta-Squared = 0.484. As shown in Figure 11, performance was faster when using a web site whose secondary menu was located on the left side (LLL, LLT, TLT, TLL) than whose secondary menu was on the top (LTT, LTL, TTT, TTL). There was no main effect for the tertiary menu level.

Table 6

Experiment 1 Navigation Time Mean Scores, Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
LTT	104.6329	19.6640	1 (Fastest Navigation Time)
TLL	111.7752	30.4876	2
LLT	114.3268	29.0247	3
TLT	115.4579	28.1456	4
LLL	121.8449	42.3231	5
LTL	123.2493	35.0409	6
TTT	142.0845	37.4468	7
TTL	166.0657	81.7732	8 (Slowest Navigation Time)

Figure 10. Experiment 1 navigation time main effect for primary menu level placement.

Figure 11. Experiment 1 navigation time main effect for secondary menu level placement.

Finally, there was a significant interaction of primary and secondary menu levels, $F(1, 15) = 14.636$, $p \leq 0.05$, Eta-Squared = 0.494. As shown in Figure 12, when the primary menu was located in the top plane, navigation times were faster when the associated secondary menu was located in the opposite, or left, pane. However, when the primary menu was located in the left plane, navigation times were roughly equivalent between the two secondary menu locations. All other interactions for navigation time were not found to be significant.

The secondary analysis for navigation time, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 4.710$, $p \leq 0.05$, Eta-Squared = 0.300. As shown in Figure 13, post-hoc comparisons showed the LTT and TLL menu structures to be significantly faster compared to all other menu structures ($p \leq 0.05$). The TTT and TTL configurations were found to be significantly the poorest performing menu structures ($p \leq 0.05$). There were no other significant differences among all other menu structures.

Figure 12. Experiment 1 navigation time interaction for primary-secondary menu levels.

Figure 13. Experiment 1 navigation time means by menu structure.

Finally, the grouped comparison analysis reveals a main effect for navigation time for location of the primary menu $F(1, 15) = 11.119$, $p \leq 0.05$, Eta-

Squared = 0.426. Navigation time was faster for those menu structures with a primary left menu (see figure 14).

Also, a main effect was found for grouping primary and secondary menu levels, $F(1, 15) = 14.636$, $p \leq 0.05$, Eta-Squared = 0.494. Navigation time was faster when the primary and secondary menus were positioned on separate planes (see Figure 15).

No main effect was found for navigation time for grouping of secondary and tertiary menu levels. However, a main effect was found for grouping of secondary and tertiary menu levels $F(1, 15) = 13.752$, $p \leq 0.05$, Eta-Squared = 0.478. Navigation time was faster when the primary menu was split from the secondary and tertiary menus (see Figure 16).

Figure 14. Experiment 1 navigation time primary level contrast comparison.

Figure 15. Experiment 1 navigation time primary-secondary contrast comparison.

Figure 16. Experiment 1 navigation time secondary-tertiary contrast comparison.

Hesitation

The mean values, standard deviations and ranking (1,best and 8, worst) for hesitation are displayed in Table 7.

Table 7

Experiment 1 Hesitation Mean Scores, Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
LTT	0.6191	0.6191	1 (Least Hesitation)
LTL	1.0646	1.0646	2
TTT	1.1547	1.1547	3
LLT	1.1832	1.1832	4
LLL	1.2230	1.2230	5
TLL	1.2366	1.2366	6
TLT	1.3647	1.3647	7
TTL	1.7842	1.7842	8 (Most Hesitation)

No main effects for hesitation were found for the primary menu level, secondary menu level, or the tertiary menu level. There was a significant interaction of secondary and tertiary menu levels, $F(1, 15) = 9.732$, $p \leq 0.05$, Eta-Squared = 0.393. As shown in Figure 17, when the secondary menu was located in the top plane, hesitation was less when the associated tertiary menu was located in the same top plane. However, when the secondary menu was located in the left plane, hesitation was slightly reduced when both the secondary and

tertiary menus were located on the left as opposed to the secondary menu on the left and tertiary menu on the top. All other interactions for hesitation were not found to be significant.

Figure 17. Experiment 1 hesitation interaction for primary-secondary menu levels.

The second analysis for hesitation, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 2.645$, $p \leq 0.05$, Eta-Squared = 0.150. As shown in Figure 18, post-hoc comparisons showed the LTT menu structure to have significantly less hesitation compared to all other menu structures, except TLL and TTT ($p \leq 0.05$). However, TTT had no significance over all other menu structures and TLL only had significance over the worst performing menu structure (LTL). No other significant differences were found among all other menu structures.

Figure 18. Experiment 1 hesitation means by menu structure.

No main effect was found for primary menu location for hesitation between the left and top placement. Additionally, no main effect was found for grouping of primary and secondary menu levels. However, a main effect was found when secondary and tertiary menu levels were grouped together $F(1, 15) = 9.732$, $p \leq 0.05$, Eta-Squared = 0.393. Hesitation was reduced when the secondary and tertiary menu levels were grouped together (see Figure 19). Finally, no main effect was found between grouped vs. split secondary-tertiary groupings.

Figure 19. Experiment 1 hesitation secondary-tertiary contrast comparison.

Cursor Movement

The mean values, standard deviations and ranking (1, best and 8, worst) for cursor movement are displayed in Table 8. There was a main effect for cursor movement for the primary menu level, $F(1, 15) = 13.058$, $p \leq 0.05$, Eta-Squared = 0.465. As shown in Figure 20, less cursor movement to the incorrect plane occurred when using a web site whose primary menu was located on the left side (LLL, LLT, LTT, LTL) than those placed at the top (TTT, TTL, TLL, TLT). There was no main effect for the secondary and tertiary menu levels.

Table 8

Experiment 1 Cursor Movement Mean Scores, Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
LLL	0.7500	0.7746	1 (Fewest Cursor Movement)
TTT	1.0000	1.3663	2
LLT	1.1875	1.4245	3
LTT	1.3750	1.0878	4
TLL	1.8125	1.7212	5
LTL	2.4375	1.7877	6
TTL	2.5625	2.3372	7
TLT	3.1250	1.7464	8 (Most Cursor Movement)

There was a significant interaction of primary and secondary menu levels, $F(1, 15) = 8.151$, $p \leq 0.05$, Eta-Squared = 0.352. As shown in Figure 21, when the primary menu was located in the top plane, cursor movement to the incorrect plane was less frequent when the associated secondary menu was also located in the top plane. When the primary menu was located in the left plane, cursor movement to the incorrect plane was less frequent when the associated secondary menu was also located in the left plane. However, there was

relatively no difference of the secondary top menu between primary left or primary top menus.

Figure 20. Experiment 1 cursor movement main effect for primary menu level placement.

Figure 21. Experiment 1 cursor movement interaction for primary-secondary menu levels.

Also, there was a significant interaction of secondary and tertiary menu levels, $F(1, 15) = 15.854$, $p \leq 0.05$, Eta-Squared = 0.514. As shown in Figure 22, when the secondary menu was located in the top plane, cursor movement to the incorrect plane was less frequent when the associated tertiary menu was located on the top plane. When the secondary menu was located in the left plane, cursor movement to the incorrect plane was less frequent when the tertiary menu was also located on the left plane. No significant interaction was found for primary and tertiary levels.

Figure 22. Experiment 1 cursor movement interaction for secondary-tertiary menu levels.

Finally, there was a significant interaction of primary, secondary and tertiary menu levels, $F(1, 15) = 4.840$, $p \leq 0.05$, Eta-Squared = 0.244. As shown in Figure 23, when the primary menu was located in the left plane, cursor

movement to the incorrect plane was less frequent when the secondary left menu was associated with a tertiary left menu. Although there was a difference between the secondary left with tertiary left and top menus, the difference was not as great compared to the difference when the secondary menu was placed at the top. When the secondary menu was placed at the top, a tertiary menu placed on the top showed less cursor movement to the incorrect plane compared to a tertiary menu on the left.

As shown in Figure 24, when the primary menu was located in the top plane, cursor movement to the incorrect plane was less frequent when both secondary and tertiary menus were also located in the top plane. However, when the secondary menu was located in the left plane, cursor movement to the incorrect plane was less frequent when the tertiary menu was also placed in the left plane.

Figure 23. Experiment 1 cursor movement for primary-secondary-tertiary menu levels with a primary left menu.

Figure 24. Experiment 1 cursor movement interaction for primary-secondary-tertiary menu levels with a primary top menu.

The secondary analysis for navigation time, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 4.710$, $p \leq 0.05$. As shown in Figure 25, post-hoc comparisons showed the LLL, LLT and TTT menu structures to have significantly fewer cursor movements compared to all other menu structures ($p \leq 0.05$). There were no other significant differences among all other menu structures.

Figure 25. Experiment 1 cursor movement means by menu structure.

The contrast comparison analysis reveal a main effect for cursor movement for primary menu location, $F(1, 15) = 13.058$, $p \leq 0.05$, Eta-Squared = 0.465. Fewer cursor movements to the wrong plane were found for menu structures that started with a primary left menu (see Figure 26). Additionally, a main effect was found for grouping primary and secondary menu levels,

$F(1, 15) = 8.151, p \leq 0.05$, Eta-Squared = 0.352. Fewer cursor movements were exhibited by menu structures that group the primary and secondary menu levels together on the same plane (see Figure 27).

There was also a main effect for grouping of secondary and tertiary menu levels, $F(1, 15) = 15.854, p \leq 0.05$, Eta-Squared = 0.514. Those structures that group the secondary and tertiary menu levels together performed better compared to all other structures (see Figure 28). No main effect was found between grouped vs. split secondary-tertiary groupings.

Figure 26. Experiment 1 cursor movement primary menu contrast comparison.

Figure 27. Experiment 1 cursor movement secondary-tertiary contrast comparison.

Figure 28. Experiment 1 cursor movement secondary-tertiary contrast comparison.

Selection Errors

The mean values, standard deviations and ranking (1, best and 8, worst) for selection errors are displayed in Table 9. There was a main effect for selection errors for the primary menu level, $F(1, 15) = 16.453$, $p \leq 0.05$, Eta-Squared = 0.523. As shown in Figure 29, fewer selection errors occurred when using a web site whose primary menu was located on the left side (LLL, LLT, LTT, LTL) than those placed at the top (TTT, TTL, TLL, TLT).

Table 9

Experiment 1 Selection Error Mean Scores, Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
LTL	0.3125	0.6021	1 (Fewest Selection Errors)
LLL	0.6250	1.5438	2
LLT	0.6875	1.3022	3
LTT	1.2500	1.8797	4
TLL	1.2500	9.0441	4
TLT	1.4375	2.2202	6
TTT	5.3750	4.8425	7
TTL	8.0625	9.0441	8 (Most Selection Errors)

Figure 29. Experiment 1 selection errors main effect for primary menu level placement.

A main effect for selection errors also was found for the secondary menu level, $F(1, 15) = 19.863$, $p \leq 0.05$, Eta-Squared = 0.570. As shown in Figure 30, fewer selection errors occurred when using a web site whose secondary menu was located on the left side (LLL, LLT, LTT, LTL) than those placed at the top (TTT, TTL, TLL, TLT). There was no main effect for the tertiary menu level.

Figure 30. Experiment 1 selection errors main effect for secondary menu level placement.

There was a significant interaction of primary and secondary menu levels, $F(1, 15) = 15.546$, $p \leq 0.05$, Eta-Squared = 0.509. As shown in Figure 31, when the primary menu was located in the left plane, the least amount of selection errors occurred when the secondary menu was placed either in the left or the top planes. However, when the primary menu was located in the top plane, fewer selection errors occurred when the secondary menu was placed in the left menu. All other interactions for selection errors were not found to be significant.

Figure 31. Experiment 1 selection errors interaction for primary-secondary menu levels.

The second analysis for selection errors, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 10.043$, $p \leq 0.05$, Eta-Squared = 0.401. As shown in Figure 32, post-hoc comparisons showed the LTL menu structure to be significantly the best performing compared to all top primary menu structures, but not significant in performance compared to all other primary left menu structures ($p \leq 0.05$). The TTL and TTT configurations were found to be significantly the poorest performing menu structures ($p \leq 0.05$). There were no other significant differences among all other menu structures.

Figure 32. Experiment 1 selection error means by menu structure.

The contrast analysis revealed a main effect for selection errors for primary menu location $F(1, 15) = 16.453$ $p \leq 0.05$, Eta-Squared = 0.523. Fewer selection errors were found for menu structures with a primary left menu (see Figure 33).

Additionally, a main effect was found for grouping primary and secondary menu levels, $F(1, 15) = 15.546$, $p \leq 0.05$, Eta-Squared = 0.509. Fewer selection errors were found in menu structures that split primary and secondary menu levels (see Figure 34).

No main effect was found for grouping of secondary and tertiary menu levels. However, a main effect was found when secondary and tertiary menu levels were grouped together, grouping all levels together compared to split from the primary menu level $F(1, 15) = 6.255$, $p \leq 0.05$, Eta-Squared = 0.294. Fewer

selection errors were found with menu structures that split the secondary and tertiary menu levels from the primary menu level (see Figure 35).

Figure 33. Experiment 1 selection errors primary menu contrast comparison.

Figure 34. Experiment 1 selection errors primary-secondary contrast comparison.

Figure 35. Experiment 1 selection errors time secondary-tertiary contrast comparison.

Overall Preference

The mean values, standard deviations and ranking (1, best and 8, worst) overall preference are displayed in Table 10. There was a main effect for overall preference for the secondary menu level, $F(1, 15) = 6.943$, $p \leq 0.05$, Eta-Squared = 0.316. As shown in Figure 36, participants preferred using a web site whose primary menu was located on the left side (LLL, LLT, LTT, LTL) than a primary menu placed at the top (TTT, TTL, TLL, TLT). No main effects were found for primary and tertiary menu levels.

Table 10

Experiment 1 Overall Preference Mean Scores, Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
LLL	11.5625	8.6792	1 (Most Preferred)
TTT	13.4375	8.7557	2
LTT	17.9315	6.1911	3
TLL	20.4375	7.6852	4
LLT	20.6875	9.6728	5
TTL	26.0625	6.5774	6
TLT	31.5000	8.6564	7
LTL	35.8125	5.6240	8 (Least Preferred)

Figure36. Experiment 1 overall preference main effect for secondary menu level placement.

There was a significant interaction of primary and secondary menu levels, $F(1, 15) = 40.336$, $p \leq 0.05$, Eta-Squared = 0.729. As shown in Figure 37, when the primary menu was located in the left plane, participants preferred the secondary menu to be located in the left plane more than the top plane. However, when the primary menu was located in the top plane, participants preferred the secondary menu to also be located in the top plane.

Figure 37. Experiment 1 overall preference interaction for primary-secondary menu levels.

There was also a significant interaction of secondary and tertiary menu levels, $F(1, 15) = 46.094$, $p \leq 0.05$, Eta-Squared = 0.754. As shown in Figure 38, when the secondary menu was located in the left plane, participants preferred a tertiary menu to be placed in the left plane. As well, when the secondary menu was placed in the top plane, participants preferred the tertiary menu to be placed in the top plane. All other interactions for overall preference were not found to be significant.

Figure 38. Experiment 1 overall preference interaction for secondary-tertiary menu levels.

The second analysis for navigation time, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 16.497$, $p \leq 0.05$, Eta-Squared = 0.524. As shown in Figure 39, post-hoc comparisons showed the LLL menu structure to be significantly preferred over all other menu structures except the TTT menu structure ($p \leq 0.05$). The TTT configuration was significant over all other configurations ($p \leq 0.05$). TLT and LTL were significantly the least preferred configurations compared to all other menu structures. No other significant differences among all other menu structures were found.

Figure 39. Experiment 1 overall preference means by menu structure.

The contrast analysis revealed no main effect for primary menu location for overall preference. However, a main effect was found for grouping primary and secondary menu levels, $F(1, 15) = 40.366$, $p \leq 0.05$, Eta-Squared = 0.729. Participants preferred grouping primary and secondary menu levels on the same plane compared to splitting the primary and secondary menus on different planes (see Figure 40).

A main effect was also found for grouping of secondary and tertiary menu levels $F(1, 15) = 46.094$, $p \leq 0.05$, Eta-Squared = 0.754. Participants preferred grouping of secondary and tertiary menu levels on the same plane (see Figure 41). Finally, a main effect together was found for the relationship between the grouping of secondary and tertiary levels to the same or different primary level plane $F(1, 15) = 9.367$, $p \leq 0.05$, Eta-Squared = 0.384. Participants preferred all

three menu levels grouped on the same plane compared to splitting the primary menu level from the secondary and tertiary menu levels (see Figure 42).

Figure 40. Experiment 1 overall preference primary-secondary contrast comparison.

Figure 41. Experiment 1 overall preference secondary-tertiary contrast comparison.

Figure 42. Experiment 1 overall preference secondary-tertiary contrast comparison grouped versus split from primary menu.

Each participant ranked the eight structures based on fastest to complete, easiest to navigate between links, easiest to navigate accurately with fewest selection errors, and overall preference. Across each measure there is a consistent ranking of the eight sites.

A correlation across all measures was performed for each survey measure. Both correlations by value and by rank for all preference measures were found to be significantly highly positive correlated. The results of this correlation by value are presented in Table 11 below and the correlation by rank in Table 12.

Table 11

Experiment 1 Survey Preference Ranking Correlation Matrix by Value

	<i>Fastest to complete tasks</i>	<i>Easiest to navigate between links</i>	<i>Easiest to navigate accurately with fewest errors</i>	<i>Most Intuitive</i>	<i>Overall Preference</i>	<i>Total Survey Preference</i>
Fastest to complete tasks	1					
Easiest to navigate between links	0.989292	1				
Easiest to navigate accurately with fewest errors	0.988101	0.980197	1			
Most Intuitive	0.990994	0.983091	0.991044	1		
Overall Preference	0.991707	0.988499	0.996481	0.996808	1	
Total Survey Preference	0.996208	0.992536	0.995288	0.996355	0.998801	1

Table 12

Experiment 1 Survey Preference Ranking Correlation Matrix by Rank

	<i>Fastest to complete tasks</i>	<i>Easiest to navigate between links</i>	<i>Easiest to navigate accurately with fewest errors</i>	<i>Most Intuitive</i>	<i>Overall Preference</i>	<i>Total Survey Preference</i>
Fastest to complete tasks	1					
Easiest to navigate between links	1	1				
Easiest to navigate accurately with fewest errors	0.976190	0.976190	1			
Most Intuitive	0.989569	0.989569	0.989569	1		
Overall Preference	0.976190	0.976190	1	0.989569	1	
Total Survey Preference	1	1	0.976190	0.989569	0.976190	1

Overall Score

An equal and adjusted weight score was calculated for each menu structure to determine any significant correlations between measures, as well as determine whether some menu structures both performed well and were most preferred among participants. Results of the equal score are presented below. See Appendix G for results of the adjusted weight scores.

Overall Score: Equal Weight. An overall equal weight score found the LTT, LLL and LLT menu structures to come out above all other menu structures. Table 13 displays the equal score and rank for each condition. A graphical representation of each site's equal score by value is shown in Figure 43 and a graphical representation of each site's equal score by rank is shown in Figure 44.

Table 13

Experiment 1 Overall Equal Weight Scores by Value and Rank

Condition	Equal Weight Score	Rank
LTT	2.6	1 (Best)
LLL	2.8	2
LLT	3.6	3
TTT	4.2	4
TLL	4.2	5
LTL	4.6	6
TLT	6.4	7
TTL	7.4	8 (Worst)

Figure 43. Experiment 1 overall equal scores by value.

Figure 44. Experiment 1 overall equal scores by rank.

Correlation of Dependent Measures

Tables 14 and 15 lists each measure in order of rank from 1, best to 8, worst and by order of value, respectively.

Table 14

Experiment 1 Ranking of All Measures by Menu Structure

Rank	Navigation Time	Selection Errors	Hesitation	Cursor Movement	Overall Preference	Equal Weight Score	Adjusted Weight Score
1	LTT	LTL	LTT	LLL	LLL	LTT	LLL
2	TLL	LLL	LTL	TTT	TTT	LLL	LTT
3	LLT	LLT	TTT	LLT	LTT	LLT	LLT
4	TLT	LTT	LLT	LTT	TLL	TLL	TTT
5	LLL	TLL	LLL	TLL	LLT	TTT	TLL
6	LTL	TLT	TLL	LTL	TTL	LTL	LTL
7	TTT	TTT	TLT	TTL	TLT	TLT	TLT
8	TTL	TTL	TTL	TLT	LTL	TTL	TTL

Table 15

Experiment 1 Ranking of Menu Structures for All Measures

Condition	Navigation Time	Selection Errors	Hesitation	Cursor Movement	Overall Preference	Equal Weight Score	Adjusted Weight Score
LLL	5	2	5	1	1	2	1
LLT	3	3	4	3	5	3	3
LTT	1	4	1	4	3	1	2
LTL	6	1	2	6	8	6	6
TTT	7	7	3	2	2	4	4
TTL	8	8	8	7	6	8	8
TLL	2	4	6	5	4	4	5
TLT	4	6	7	8	7	7	7

Table 16

Experiment 1 Correlation of Performance and Preference Data by Rank

	<i>Navigation Time</i>	<i>Selection Errors</i>	<i>Hesitation</i>	<i>Cursor Movement</i>	<i>Overall Preference</i>	<i>Adjusted Weight Score</i>	<i>Equal Weight Score</i>
Navigation Time	1						
Selection Errors	0.393443	1					
Hesitation	0.309524	0.512668	1				
Cursor Movement	0.095238	0.321908	0.452381	1			
Overall Preference	0.166667	-0.01192	0.214286	0.857143	1		
Adjusted Weight Score	0.47619	0.512668	0.571429	0.880952	0.785714	1	
Equal Weight Score	0.631893	0.474627	0.631893	0.798809	0.751119	0.965724	1

Based on the data for correlation for all measures by rank, in Table 16, the information listed in Table 17 is a breakdown of all high significant correlations, positive trends, neutral to near neutral trends and negative trends.

Navigation Time vs. Preference

A correlation of values and rank was performed with navigation time and preference to see if there is a high or low correlation between the two measures. No significant correlation was found between total preference and navigation time by rank or by value. The results of each correlation by rank and value are found in Tables 18 and 19, respectively.

Table 17

Breakdown of Experiment 1 dependent measure correlations

High significant correlations:

- ☐ Cursor Movement- Overall Preference
- ☐ Cursor Movement -Adjusted Weight Score
- ☐ Cursor Movement - Equal Weight Score
- ☐ Overall Preference- Adjusted Weight Score
- ☐ Overall Preference – Equal Weight Score
- ☐ Equal Score- Cursor Movement
- ☐ Adjusted Weight Score - Equal Weight Score

Positive Trends:

- ☐ Navigation Time- Selection Errors
- ☐ Navigation Time - Hesitation
- ☐ Navigation Time - Adjusted Weight Score
- ☐ Navigation Time -Equal Weight Score
- ☐ Selection Errors -Hesitation
- ☐ Selection Errors -Cursor Movement
- ☐ Selection Errors - Adjusted Weight Score
- ☐ Selection Errors- Equal Weight Score I
- ☐ Hesitations-Cursor Movement
- ☐ Hesitation- Adjusted Weight Score
- ☐ Hesitation- Equal Weight Score

Neutral to Near-Neutral Trends:

- ☐ Navigation Time -Cursor Movement
- ☐ Navigation Time - Overall Preference
- ☐ Hesitation- Overall Preference

Negative Trends:

- ☐ Selection Errors- Overall Preference
-

Table 18

Experiment 1 Correlation of Navigation Time vs. Overall Preference by Rank

	<i>Overall Preference</i>	<i>Navigation Time</i>
Overall Preference	1	
Navigation Time	0.166667	1

Table 19

Experiment 1 Correlation of Navigation Time vs. Overall Preference by Value

	<i>Overall Preference</i>	<i>Navigation Time</i>
Overall Preference	1	
Navigation Time	0.038019	1

EXPERIMENT 1: DISCUSSION

Navigation Time

Main effects were found for both the primary and secondary menu levels, with the left side performing better over the top, in both cases. This supports Bernard's (2001) study of users' schemas and preferences for menu location, but does not support the Gathman et al (1988) study finding time to navigate faster with a menu positioned at the top. This may be due to the more complicated (3-tier) menu structure used in the present study. The location of the tertiary menu level did not influence navigation time.

The interaction between primary and secondary menu levels suggests that when the primary menu is located on the left side, performance is unaffected by the location of the secondary menu. However, when the primary menu is located at the top, navigation times are faster when the secondary menu is located on the left side.

Another way to look at this result is to describe the primary and secondary menu levels as being either spatially grouped or separated. When the primary menu is located on the left side, spatial grouping is unimportant. That is, when the primary menu is on the left, it does not make a difference whether the secondary menu is placed on the left or top portion of the page. Yet, when the primary menu is located at the top, spatial grouping has a significant effect. We will refer to this distinction in subsequent sections of the discussion.

Although the secondary and tertiary menu levels did not interact, they showed a similar trend to the primary-secondary menu interaction. That is, performance was better (faster) when the secondary and tertiary menu levels were grouped on the same plane (XLL and XTT, mean = 120.08) than when they were separated (XLT and XTL, mean = 129.77).

When viewing the conditions as a collection of individual menu structures, the two fastest menu structures for navigation were the LTT and TLL structures. From a design perspective, these structures are similar in that one is a rotation of the other, both composed of a primary menu split from the secondary and tertiary menus. This is an important finding that supports one of the study's hypotheses, that grouping secondary and tertiary menus together on the same plane will benefit performance. One should also note that these conditions performed better than other secondary-tertiary same plane conditions that retain all menu levels on the same plane (LLL and TTT).

One explanation for these results is that the secondary and tertiary menus are more related to one another than the primary and secondary levels. The primary levels are product categories, whereas the secondary and tertiary levels relate to brands and types, which are more closely associated with one's mental model that places the latter types of information as closer nodes in working memory.

The TTT menu scheme may have performed poorly due to visual clutter. Keeping the eyes on the same plane may save time in terms of cursor

movements, but it may also increase the time for visual scanning and processing of information since there is more information grouped together in a small space. TTT also had higher selection errors compared to other menu conditions, which could have influenced its overall navigation time.

To determine the difference between a focus on the location of the primary menu versus the grouping of secondary and tertiary menus, a calculation of “savings” was conducted to determine how much of a difference is gained or lost by placing more focus on one principle over the other. Using a primary left menu (L, mean = 116.013) produces a savings of approximately 17 seconds in navigation time compared to a top primary menu (T, mean = 133.846). The contrast comparison between primary-left and primary-top menus supports this finding. Grouping secondary and tertiary menus together (XLL and XTT, mean = 120.084) compared to grouping primary and secondary menus together on the same plane (LLX and TTX, mean = 129.775) produces a savings of approximately 9 seconds. For all conditions that group the secondary and tertiary on the same plane, splitting the primary from the secondary and tertiary menus (LTT and TLL, mean = 108.204) saves 23 seconds over those that retain all menu levels on the same plane (LLL and TTT, mean = 131.965).

These results suggest that both principles are important, with the location of the primary menu the dominant factor, and grouping of secondary and tertiary menus together being a significant, but less dominating factor. These two

principles combine to predict the LTT menu as the best performing spatial architecture, which is consistent with our findings (see Table 6).

Hesitation

Unlike navigation time, primary, secondary or tertiary menu levels had no significant influence on hesitation, although the LTT menu structure was again the best performing. The interaction of secondary and tertiary menu levels suggest that when the secondary menu is located on the left side, hesitation is unaffected by the location of the tertiary menu. However, when the secondary menu is located at the top, hesitation is less likely to occur when the tertiary menu are grouped in the same location.

Although the primary and secondary levels did not have a significant interaction, they showed the opposite trend. That is, hesitation was less when the primary and secondary menus were not grouped together on the same plane (LT and TL, mean = 1.13) than when they were grouped together (LL and TT, mean = 1.27).

When viewing the conditions as a collection of individual menu schemes, the LTT scheme showed the least amount of hesitation, followed by the LTL scheme. Recall that the LTT scheme also performed fastest for navigation time. A positive correlation was found between these two measures, although not significant.

Following the LTT and LTL menu structures, the TTT, LLT and LLL menu structures had less hesitation. All three group the primary and secondary menu

levels together on the same plane. Such grouping could produce less hesitation since the cursor is positioned in the same plane, reducing the time needed to move the cursor to make a selection, rather than moving to another portion of the screen to make a selection.

The calculation of “savings” is relatively small for hesitation among all levels and groupings. Little savings is seen in primary menu location, with a left primary menu (L, mean = 1.141) performing better over a top primary menu (T, mean = 1.250). Grouping secondary and tertiary menus on the same plane (XLL and XTT, mean = 0.875) show greater savings with less hesitation compared to grouping primary and secondary menus on the same plane (LLX and TTX, mean = 1.516). Finally the difference in secondary-tertiary menu groupings favors a split in planes of the primary and secondary menus (XLT and XTL, mean = 0.656) over grouping all menus in the same plane (XLL and XTT, mean = 1.094).

The results suggest that grouping of secondary and tertiary is the more dominant factor, and the location of the primary menu is less of a factor. Once more, these two principles combine to predict the LTT menu as the best performing spatial architecture, which is consistent with our findings (see Table 7).

Cursor Movement

Cursor movement was defined as a movement to the incorrect plane during a navigation task from any one level to any other level. Main effects were found for the primary menu levels, with the left location resulting in fewer

unnecessary cursor movements than the top location. This is consistent with the navigation time and hesitation findings for primary menu location. The location of secondary and tertiary menu levels did not influence cursor movement.

The interaction between primary and secondary menu levels suggests that when the primary menu is located on the left, cursor movement is reduced when the secondary menu is also located on the left side (grouped) rather than the top side. However, when the primary menu is located at the top, performance is unaffected by the location of the secondary menu. Describing these results in terms of spatial grouping, when the primary menu is located on the top, spatial grouping is unimportant. Yet, when the primary menu is located on the left side, performance is aided when by grouping both levels on the same plane.

The interaction between secondary and tertiary menus also suggests a greater significance for grouping secondary and tertiary menu levels on the same plane. When the secondary menu is located either on the left or top, having the tertiary menu on the same plane produces less cursor movement than when these menus are split apart. Therefore, spatial grouping of secondary and tertiary menus on the same plane has a significant influence on reducing cursor movement.

The interaction of all menu levels showed less hesitation for a primary left menu over a primary top menu. When the primary menu was on the left side and the secondary menu is located on the left side, cursor movement is unaffected by the location of the tertiary menu. However, when the secondary menu is located

at the top, cursor movement is reduced when the tertiary menu is also located on at the top. When the primary menu was located at the top, and the secondary menu is located at the top, cursor movement is less when the tertiary is also grouped on the top rather than on the left. However, when the secondary menu is located on the left side, cursor movement is reduced when the tertiary menu is located on the left side. Describing these results as a factor of grouping, when the primary menu is on either the left or top, grouping of primary and secondary menus together had a significant effect. As well, grouping of secondary and tertiary menus together had a significant effect regardless of primary menu location.

Viewing the conditions as a collection of individual menu schemes, the two best performing (least amount) for cursor movement were the LLL and TTT structures. From a design perspective, both structures group all menus levels together on a single plane. This finding supports the hypotheses for grouping secondary and tertiary menus on the same plane.

One explanation for the reduced cursor movement with these menu structures is a similar explanation and result that occurred with hesitation. A menu structure that groups menus together on the same plane, such as LLL or TTT, does not require users to move their cursor to another portion of the screen. Therefore, incorrect cursor movements are not as likely to occur compared to when the menus are split between two different sections of the screen, with

information adding more information to process, increasing the likelihood to move to another plane.

The results suggest all levels should be grouped with the primary menu on the same plane, rather than separating the primary menu on a different plane from the secondary and tertiary menu levels. Taking the grouping of all menus on the same plane (LLL, TTT) out of the equation, the LLT, LTT and TLL structures produce the least amount of hesitation. Two of the three structures group the secondary and tertiary menus on a different plane from the primary menu.

The “savings” associated with cursor movement, to determine the focus between primary menu and grouping of secondary and tertiary menus, show a savings in primary menu location with a primary left menu (L, mean = 1.438) having less cursor movement compared to a primary top menu (T, mean = 2.125). A savings is also found for grouping of secondary and tertiary menus on the same plane (XLL and XTT, mean = 1.234) rather than grouping primary and secondary menus on the same plane (LLX and TTX, mean = 2.328). For all conditions that group all levels on the same plane fewer incorrect cursor movements were exhibited (LLL and TTT, mean = 0.875) compared to those conditions that split the primary menu from the secondary and tertiary menus (LTT and TLL, mean = 1.594).

These results suggest that both principles are important, with the grouping of secondary and tertiary menus as the dominant factor, and the location of the primary menu being a significant, but less dominant factor. These two principles

combine to predict the LLL menu structure as the best performing spatial architecture, which is consistent with our findings (see Table 8).

Selection Errors

Main effects were found for both the primary and secondary menu levels, with the left side performing better (fewer selection errors) than at the top in both cases. These results are consistent for the location of the primary menu for navigation time and cursor movement. The location of the tertiary menu level did not influence selection errors.

The interaction between primary and secondary menu levels suggests that when the primary menu is located on the left side, performance is unaffected by the location of the secondary menu. However, when the primary menu is located at the top, selection errors are less when the secondary menu is located on the left side. Another way to describe this result is, when the primary menu is located on the left side, spatial grouping is unimportant. However, when the primary menu is located at the top, spatial grouping has a significant effect.

Although the secondary and tertiary menu levels did not produce a significant interaction, they showed a similar trend to the primary-secondary menu interaction. That is, fewer errors occurred when the secondary and tertiary menu levels were grouped on the same plane than when they were separated.

When viewing the conditions as a collection of individual menu schemes, the top four structures with the least selection errors were the LTL, LLL, LLT, and LTT structures. All structures have a primary left menu. This is an important

finding for the position of the primary menu, with a primary left menu better at reducing selection errors compared to a top primary menu.

One explanation for the LTL condition having the least number of selection errors is due to a speed-accuracy trade-off (Wickens and Hollands, 2000). Since this condition generally performed poorly across other measures, and was given the lowest subjective ratings of all conditions, it could be that the additional effort and concentration required (and perceived to be required) by this condition produced the added benefit of more accurate navigation. Simply stated, participants found this condition difficult and therefore could not navigate it in a quick and automatic fashion. At the same time, the slower and more cautious approach produced more accurate link selections.

Fewer selection errors occurred for LLL and LLT, both grouping primary and secondary menu levels together on the left plane. Grouping both menu levels, vertically on the left plane, is easier to read and process the hierarchy of information compared to two menus grouped on the top. Additionally, the cursor is primed for selection in the same plane since there is no need to drastically move the cursor across the screen to make a selection in the opposite plane.

The TTT and TTL structures performed worst with the most selection errors. Note these are the similar menu structures to LLL and LLT, which had less hesitation as discussed above. One explanation for the higher hesitation associated with these structures is due to the visual clutter in the design of the hierarchies at the top of the screen. Each web site was designed to be as bare

as possible, reducing any other influence on navigation, other than placement of menu levels. For top menu levels the design presents each link evenly across with each sub level centered below the related menu. Depending on the length of second level category names, some second level links are positioned within the space devoted to a different primary level, making the second level appear to be associated with a different primary level menu than its actual primary level menu. Another reasoning for high hesitation is attributed to the category types of toys (TTT) and books (TTL) used for these conditions. It may be that the familiarity with such categories is less than with more popular categories such as sports or clothing.

Using a left primary menu (L, mean = 0.719) reduces selection errors by 80% compared to a top primary menu (T, mean = 4.031). When secondary and tertiary menu levels were placed on the same plane (XLL and XTT, mean = 1.234) selection errors were reduced compared to splitting secondary and tertiary menus (XLT and XTL, mean = 2.328). For all conditions that group the secondary and tertiary menus on the same plane, splitting the primary menu from the secondary and tertiary menu (LTT and TLL, mean = 1.594) increases selection errors by double compared to those conditions that retain all menu levels on the same plane (LLL and TTT, mean = 0.875).

These results suggest that the location of the primary menu is the dominant factor for selection errors, and the grouping of secondary and tertiary menus is an important, but less significant finding. These two principles combine

to predict the reduced selection errors for all primary left menu structures (LLL, LLT, LTT, and LTL) (see Table 9).

Overall Preference

A main effect was found for the secondary menu level with the left side preferred over the top. The primary and tertiary menu levels did not influence overall preference, although the trends indicated that the left side was favored over the top for both levels.

The interaction between primary and secondary menu levels suggests that when the primary menu is placed on the left, a secondary left menu was preferred over a secondary top menu. When the primary menu is placed on the top, a secondary top menu is preferred over a secondary left menu. Stated another way, whether the primary menu is located on the top or the left, the participants preferred the secondary menu to be grouped in the same location.

The interaction between secondary and tertiary menu level interaction also showed a similar trend to the primary-secondary interaction. That is, participants preferred when the secondary and tertiary menus levels were grouped on the same plane over when they were separated.

Viewing the conditions as a collection of individual menu schemes, the two most preferred structures were the LLL and TTT structures. From a design perspective, these structures are similar in their menu placement, grouping all menu levels on the same plane. Participants commented in their post interaction surveys that these conditions were “not confusing,” “to the point,” consistent,”

and “easy to follow.” See Appendix L for additional comments made for these and other conditions in the post interaction survey summary.

The LTT and TLL were then preferred followed by LLT and TTL. Note that both structures, in each grouping, are similar in their menu placement, grouping the primary and secondary in one plane and the tertiary menu on the opposite plane. Those participants who preferred the LTT and TLL these menu conditions commented on how these conditions, although had a split between menus, felt once the transition was made they preferred staying on the same plane. “The first menu on the top but the rest at left is also easy,” and “it jumps but then stays the same,” were some of the benefits for these structures.

Finally, the LTL and TLT structures made up the final division with the least preferred conditions. Again, both structures have the same pattern of menu placement. Many participants commented that these conditions were “jumpy,” “confusing,” “took too much time,” and were “hard to follow with one’s eyes.”

The difference gained by placing the primary menu on the left (L, mean = 21.50) is not much over a primary menu that is placed at the top (T, mean = 22.859). A significant savings was found for grouping the primary and secondary menus together on the same plane (LLX and TTX, mean = 17.938) compared to splitting the primary and secondary menus across different planes (LTX and TLX, mean = 26.422). Similarly, a savings for grouping secondary and tertiary menus on the same plane (XLL and XTT, mean = 15.844) is seen compared to splitting secondary and tertiary menus between different planes (XLT and XTL, mean =

28.516). Finally, within grouping of secondary and tertiary menus, retaining all menus on the same plane (LLL and TTT, mean = 12.500) is more preferred than splitting the primary menu from secondary and tertiary menus (LTT and TLL, mean = 19.188).

These results suggest that both principles are important, with the grouping of the secondary and tertiary menus together being the dominant factor, and the location of the primary menu to be a less significant factor. These two principles combine to predict the LLL and TTT menu structures to be the most preferred spatial architecture, which is consistent with our findings (see Table 10).

Survey Measures

Participants were consistent in their ranking of subjective measures for fastest to complete, easiest to navigate, fewest errors, most intuitive and overall preference across all menu structures, ranking LLL and TTT as the more preferred structures.

Overall Scores

The equal weight and adjusted weight overall scores produce similar results with only two conditions swapping their ranking position. Combining performance and preference data, the LLL and LTT were the better menu structures over all other conditions.

Both equal and adjusted weightings favor a primary left menu over the top menu. Additionally, both favor grouping of secondary and tertiary menu levels over grouping of primary and secondary menu levels. These results support our

hypothesis for grouping secondary and tertiary menus split from the primary menu, such as the LTT or TLL menu structures.

Measurement Integration

Overall, the LLL and LTT menu structures came out as the best performing and preferred. There is inconsistency of results between the performance navigation time data and overall preference survey data. Even within the performance measures, different measures vary in the order of results. This common phenomenon, known as “performance preference dissociation” (c.f. (Andre & Wickens, 1995), is very common. Typically those conditions that perform the best are not always preferred, or recalled as being the best performing.

Summary

No single structure was consistent across all performance and preference measures of the eight left and top menu conditions. A primary left menu is favored for most measures, as well as a grouping of secondary and tertiary menu levels. Overall, LLL and LTT appear to be the best menu structures to use taking all performance and preference measures into account.

Starting with a primary menu on the left is a logical starting point since it has commonly been used online, and prior studies support users preference and expectation for a navigation to be placed on the left side (Bernard, 2001). Additionally, we read from left to right, therefore the progression of starting out on

the left and working our way out away from the left side of the screen is an innate habit.

LLL has an advantage over LTT from in performance with less hesitation, fewer incorrect cursor movements and less selection errors and more preferred. However, LTT has an advantage for being faster for navigation time, saving on average approximately 17 seconds over the LLL menu structure. From a design perspective LTT produces more screen real estate on the screen by splitting menus compared to using only the left side for all menus. Depending on the number of links for each menu level, placing all levels on the left could require users to use the scroll bar to navigate to menu levels. Scrolling is viewed as a disadvantage among most web users.

The LLL and LTT menu structures both have advantages and disadvantages for their use for three-level menu architecture. This is only the start to three-level menu research. Further analysis of what factors influence differences between the two structures is needed to continue to answer the question of which menu structure should be applied in the design of three-level menus.

EXPERIMENT 2: METHOD

Experimental Design

The second study was conducted to further explore the benefits of secondary and tertiary groupings, as well as determine if using a primary right hand menu proved to be better from both a performance and preference perspective. A non-factorial within-subjects design was used, with eight conditions as shown in Table 20. The eight conditions were composed of the four conditions that paired secondary and tertiary menus together from the first study (LLL, TTT, LTT, and TLL), with three-level menu structures that placed the primary menu on the right side of the screen. Four conditions consisted of the primary menu levels placed on the right side of the page with secondary and tertiary menus on either the right or top planes (RRR, RRT, RTT, and RTR). These conditions allowed us to compare all combinations of vertical-left or horizontal-top menu navigation schemes, from the first experiment, with those with a vertical-right side primary menu navigation scheme.

Participants

Sixteen undergraduate psychology students were given 2 hours of course credit to participate in this study. All participants were experienced Web users, with a wide range of web site use (self-reported). None of the participants that participated in Experiment 2 participated in Experiment 1.

Table 20

List of Menu Structures Used for Experiment 2

Condition #	Menu Layout (primary-secondary-tertiary)
1	RRR
2	RRT
3	RTT
4	RTR
5	TTT
6	LLL
7	LTT
8	TLL

Apparatus

The same apparatus used in Experiment 1 was used in Experiment 2. Refer to the Apparatus section for Experiment 1 for more details of the experimental apparatus.

Stimuli

A similar set of stimuli used in Experiment 1 was used in Experiment 2. Those menu structures not used from Experiment 1 were replaced by one of the four primary right menu structures for Experiment 1. Refer to the Stimuli section for Experiment 1 for more details of the experimental stimuli. See Appendix M for the interaction order for Experiment 2.

Dependent Measures

The same set of dependent measures used in Experiment 1 was used in Experiment 2. For more information refer to the Dependent Measures section in Experiment 1. Refer to the Dependent Measures section of Experiment 1 for more details of experimental dependent measures.

Procedure

The same procedure used in Experiment 1 was used in Experiment 2. Refer to the Procedure section in Experiment 1 for more details of the experimental procedure. See Appendices N and O, for the Experiment 2 post interaction survey and survey summaries, respectively.

EXPERIMENT 2: RESULTS

Based on data from video analysis, tracking software and final surveys, a statistical analysis for both performance and preference data was conducted to determine the level of significance of results. Navigation time, selection errors, hesitation, cursor movements and overall preference for each participant were analyzed using an individual repeated measures analysis of variance (ANOVA). For each measure the mean value, standard deviation, rank (1, best to 8, worst) and graphical representation of values are presented below. When possible an analysis of any significant correlations was conducted. Level of significance for this study was defined to be $\alpha \leq 0.05$.

To further determine significance of different menu placement and groupings selected contrast ANOVAs was conducted to determine any differences between those menu structures with similar menu groupings from all other menu structures. This resulted in five additional analyses: 1) overall comparison of primary menu location of left (LLL & LTT), top (TTT, TLL) and right (RRR, RRT, RTT, RTR) primary menus, 2) the same set of conditions listed above (LLL & LTT vs. TTT & TLL vs. RRR & RTT), excluding the RRT and RTR structures, 3) comparison of the three menu structures that group all levels on the same plane (LLL vs. TTT vs. RRR), 4) the four three-level menu structures which group the primary and secondary menu levels on the same plane (LLL, TTT, RRR, RTT) were collectively compared against all other menu structures (LTT, TLL, RRT, RTR), and finally 5) within those menu structures that group the

secondary and tertiary menu levels together a collective comparison between those menu structures that group all menu levels on the same plane (LLL, TTT, RRR) from those menu structures where the primary menu level was split from the secondary and tertiary menu levels (LTT, TLL, RTT).

Navigation Time

The mean values, standard deviations and ranking (1, best and 8, worst) for navigation time are displayed in Table 21.

Table 21

Experiment 2 Navigation Time Mean Values and Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
LTT	101.0331	15.7008	1 (Fastest Navigation Time)
RRT	106.7350	30.9534	2
TLL	107.1563	14.6998	3
RTT	111.3344	21.6032	4
LLL	111.4744	20.9164	5
RRR	115.7694	29.7251	6
RTR	122.5106	19.5632	7
TTT	128.1056	33.5433	8 (Slowest Navigation Time)

The analysis for navigation time, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 4.319$, $p \leq 0.05$, Eta-Squared = 0.224. As shown in Figure 45, post-hoc comparisons showed the LTT menu structures

to be significantly faster over all other menu structures, except RRT and TLL, ($p \leq 0.05$). The TTT configuration was found to be significantly the poorest performing menu structure ($p \leq 0.05$). There were no other significant differences among all other menu structures.

Figure 45. Experiment 2 navigation time means by menu structure.

A main effect was found for location of the primary menu $F(1, 15) = 6.458$, $p \leq 0.05$, Eta-Squared = 0.301 (see Figure 46). A primary left menu performed faster, followed by a primary right menu and primary top menu.

Similarly, a main effect for navigation was found for primary menu location among grouped secondary and tertiary menu levels, excluding RRT and RTR $F(1, 15) = 4.817$, $p \leq 0.05$, Eta-Squared = 0.408. Grouping on the left (LLL & LTT) was faster for navigation time over a primary right (RRR & RTT) or primary top menu (TTT & TLL) (see Figure 47).

A main effect was also found among the three menu structures that group all menu levels on the same plane $F(1, 15) = 4.129$, $p \leq 0.05$, Eta-Squared = 0.216 (see Figure 48). No effects were found for primary secondary grouping. Finally, a main effect was found when secondary and tertiary menu levels were grouped together, grouping all levels together compared to split from the primary menu level $F(1, 15) = 6.221$, $p \leq 0.05$, Eta-Squared = 0.293 (see Figure 49).

Figure 46. Experiment 2 navigation time primary menu contrast comparison.

Figure 47. Experiment 2 navigation time primary menu contrast comparison, excluding RRT and RTT.

Figure 48. Experiment 2 navigation time contrast comparison three same plane menu structures.

Figure 49. Experiment 2 navigation time secondary-tertiary contrast comparison grouped versus split from primary menu.

Hesitation

The mean values, standard deviations and ranking (1, best and 8, worst) for hesitation are displayed in Table 22.

The analysis for hesitation, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 7.176$, $p \leq 0.05$, Eta-Squared = 0.324. As shown in Figure 50, post-hoc comparisons showed the LTT menu structures to be significantly faster compared to the two worst performing menu structures, RTR and RRT, ($p \leq 0.05$). There were no other significant differences among all other menu structures.

Table 22

Experiment 2 Hesitation Mean Values and Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
LTT	0.0625	0.2500	1 (Least Hesitation)
LLL	0.1875	0.4031	2
RRR	0.1875	0.5439	2
RTT	0.1875	0.5439	2
TLL	0.2500	0.4472	5
TTT	0.3125	0.6021	6
RRT	0.4375	0.6292	7
RTR	1.1875	0.8342	8 (Most Hesitation)

Figure 50. Experiment 2 hesitation mean by menu structure.

No main effect for hesitation was found for primary menu location. Also, no main effect was found among the three menu structures that group all menu levels. Similarly, no main effect was found for grouping of primary and secondary menus. A main effect was found for location of the primary menu $F(1, 15) = 5.468$, $p \leq 0.05$, Eta-Squared = 0.267 (see Figure 51). Finally, no main effect together was found when secondary and tertiary menu levels were grouped together, grouping all levels together compared to split from the primary menu level.

Figure 51. Experiment 2 hesitation primary menu contrast comparison.

Cursor Movement

The mean values, standard deviations and ranking (1,best and 8, worst) for cursor movement are displayed in Table 23.

The analysis for navigation time, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 12.510$, $p \leq 0.05$, Eta-Squared =

0.455. As shown in Figure 52, post-hoc comparisons showed the LLL, RRR and TTT menu structures to be significantly faster compared to all other menu structures ($p \leq 0.05$). The RTR configuration was found to be significantly the poorest performing menu structure ($p \leq 0.05$). There were no other significant differences among all other menu structures.

Table 23

Experiment 2 Cursor Movement Mean Values and Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
LLL	0.1250	0.3416	1 (Least Cursor Movement)
RRR	0.1875	0.5439	2
TTT	0.1875	0.4031	2
LTT	0.8125	0.9811	4
TLL	1.0000	0.9661	5
RRT	1.1250	1.1475	6
RTT	1.5625	1.3150	7
RTR	2.4375	1.2093	8 (Most Cursor Movement)

Figure 52. Experiment 2 cursor movement by menu structure.

A main effect was found for location of the primary menu $F(1, 15) = 9.482$, $p \leq 0.05$, Eta-Squared = 0.575. A primary left menu had fewer cursor movements to the wrong plane over the primary top and primary right menu structures (see Figure 53). However, no main effect for cursor movement was found for primary menu location excluding the RRT and RTR menu structures. Similarly, no main effect was found among the three menu structures that group all menu levels.

A main effect was found for grouping of primary and secondary menus on the same plane $F(1, 15) = 77.308$, $p \leq 0.05$, Eta-Squared = 0.838 (see Figure 54). Finally, a main effect together was found when secondary and tertiary menu levels were grouped together, grouping all levels together compared to split from the primary menu level $F(1, 15) = 38.333$, $p \leq 0.05$, Eta-Squared = 0.719 (see Figure 55).

Figure 53. Experiment 2 cursor movement primary menu contrast comparison.

Figure 54. Experiment 2 cursor movement primary-secondary menu contrast comparison.

Figure 55. Experiment 2 cursor movement secondary-tertiary contrast comparison grouped versus split from primary menu.

Selection Errors

The mean values, standard deviations and ranking (1,best and 8, worst) for selection errors are displayed in Table 24.

The analysis for selection errors, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 4.057$, $p \leq 0.05$, Eta-Squared = 0.213. As shown in Figure 56, post-hoc comparisons showed the RTR configuration to be significantly the poorest performing menu structure ($p \leq 0.05$). There were no other significant differences among all other menu structures.

Table 24

Experiment 2 Selection Error Mean Values and Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
LLL	0.0625	0.2500	1 (Fewest Selection Errors)
RRR	0.1250	0.3416	2
LTT	0.3125	0.8732	3
RRT	0.5625	1.4127	4
TLL	0.7500	1.1832	5
RTT	0.7500	1.4376	5
RTR	0.8750	1.3601	7
TTT	2.1250	2.2767	8 (Most Selection Errors)

Figure 56. Experiment 2 selection errors mean by menu structure.

A main effect was found for location of the primary menu $F(1, 15) = 5.556$, $p \leq 0.05$, Eta-Squared = 0.442. A primary left menu performed almost equal to a primary right menu, both significantly better than a primary top menu (see Figure 57). Additionally, a main effect for primary menu location excluding the RRT and RTR menu structures was found $F(1, 15) = 5.902$, $p \leq 0.05$, Eta-Squared = 0.457. Primary left and right menus had fewer selection errors over primary top menus structures (see Figure 58).

A main effect was found among the three menu structures that group all menu levels on the same plane $F(1, 15) = 6.240$, $p \leq 0.05$, Eta-Squared = 0.471. The LLL and RRR menu structures performed better over the TTT menu structure (see Figure 59).

No main effect was found for grouping of primary and secondary menus on the same plane. Finally, no main effect together was found when secondary and tertiary menu levels were grouped together, grouping all levels together compared to split from the primary menu level.

Figure 57. Experiment 2 selection errors primary menu contrast comparison.

Figure 58. Experiment 2 selection errors primary menu contrast comparison, excluding RRT and RTT.

Figure 59. Experiment 2 selection errors contrast comparison three same plane menu structures.

Overall Preference

The mean values, standard deviations and ranking (1, best and 8, worst) for overall performance are displayed in Table 25. The analysis for navigation time, using a single factor, 8-level ANOVA, revealed a significant main effect, $F(1, 7) = 6.358$, $p \leq 0.05$, Eta-Squared = 0.298. As shown in Figure 60, post-hoc comparisons showed the RTR configuration to be significantly the poorest performing menu structure ($p \leq 0.05$). There were no other significant differences among all other menu structures.

Table 25

Experiment 2 Overall Preference Mean Values and Standard Deviation by Rank

Condition	Mean Value	Standard Deviation	Rank
RRR	15.6250	11.1348	1 (Most Preferred)
LLL	16.2500	9.5254	2
TTT	19.6875	10.5875	3
RTT	21.6250	7.0887	4
RRT	23.1250	9.9121	5
LTT	23.9375	7.8949	6
TLL	24.7500	8.7216	7
RTR	35.0000	6.1210	8 (Least Preferred)

Figure 60. Experiment 2 overall preference means by menu structure.

No main effect for overall preference was found for primary menu location, both including and excluding the RRT and RTR menu structures. Also, no main effect was found among the three menu structures that group all menu levels on the same plane.

However, a main effect was found for grouping of primary and secondary menus on the same plane $F(1, 15) = 14.780$, $p \leq 0.05$, Eta-Squared = 0.496. Participants preferred menu structures that grouped the primary and secondary menu levels on the same plane over those that split the primary menu level from secondary and tertiary menu levels (see Figure 61).

Finally, a main effect was also found for grouping of secondary and tertiary menu levels on the same plane, compared to split from the primary menu level $F(1, 15) = 6.988$, $p \leq 0.05$, Eta-Squared = 0.318. Participants preferred all levels grouped on a single plane over those structures that split the primary menu from secondary and tertiary menu levels (see Figure 62).

Figure 61. Experiment 2 overall preference primary-secondary level contrast comparison.

Figure 62. Experiment 2 overall preference secondary-tertiary contrast comparison grouped versus split from primary menu.

Each participant ranked the eight conditions based on fastest to complete, easiest to navigate between links, easiest to navigate accurately with fewest errors, and overall preference. A correlation across all measures was performed for each survey measure. Across each measure there is a consistent ranking of the eight sites across all survey rankings. Both correlation by value and correlation by rank showed all correlations to be significantly highly positive correlated. The results of survey correlations by value and by rank are presented in Tables 26 and 27, respectively.

Table 26

Experiment 2 Correlation of Survey Measures by Value

	<i>Fastest to complete tasks</i>	<i>Easiest to navigate between links</i>	<i>Easiest to navigate accurately with fewest errors</i>	<i>Most Intuitive</i>	<i>Overall Preference</i>	<i>Total Survey Preference</i>
Fastest to complete tasks	1					
Easiest to navigate between links	0.954324	1				
Easiest to navigate accurately with fewest errors	0.979722	0.972719	1			
Most Intuitive	0.970108	0.967105	0.991137	1		
Overall Preference	0.985222	0.984934	0.996002	0.992290	1	
Total Survey Preference	0.985356	0.986773	0.992815	0.989926	0.999159	1

Table 27

Experiment 2 Correlation of Survey Measures by Rank

	<i>Fastest to complete tasks</i>	<i>Easiest to navigate between links</i>	<i>Easiest to navigate accurately with fewest errors</i>	<i>Most Intuitive</i>	<i>Overall Preference</i>	<i>Total Survey Preference</i>
Fastest to complete tasks	1					
Easiest to navigate between links	0.846498	1				
Easiest to navigate accurately with fewest errors	0.918033	0.976190	1			
Most Intuitive	0.870343	0.976190	0.952381	1		
Overall Preference	0.918033	0.976190	1	0.952381	1	
Total Survey Preference	0.918033	0.976190	1	0.952381	1	1

Overall Score

An equal and adjusted weight score was calculated for each menu structure to determine any significant correlations between measures, as well as determine whether some menu structures both performed well and were most preferred among participants. Results of the equal score are presented below. See Appendix G for results of the adjusted weight scores.

Overall Score: Equal Weight. The overall equal weight scores for each site showed the LLL, RRR, TTT and LTT menu structures to be the top four structures, taking all measures into account. Table 28 displays the equal weight scores and rank for each of the menu structures. A graph of each menu structure's mean overall equal weight score is shown in figure 63.

Figure 63. Experiment 2 overall equal weight scores by rank

Table 28

Experiment 2 Overall Equal Weight Scores by Rank

Condition	Equal Weight Score	Rank
LLL	2.2	1 (Best)
RRR	2.6	2
TTT	4.0	3
LTT	4.4	4
RTT	4.4	5
RRT	4.8	6
TLL	5.2	7
RTR	7.6	8 (Worst)

Correlation of Dependent Measures

Tables 29 and 30 list each measure in order of rank from 1, best to 8, worst and by order of value, respectively.

Table 29

Experiment 2 Ranking of All Measures by Menu Structure

Rank	Navigation Time	Selection Errors	Hesitation	Cursor Movement	Overall Preference	Equal Weight Score	Adjusted Weight Score
1	TTT	LLL	LTT	LLL	RRR	LLL	LLL
2	RRT	RRR	LLL	TTT	LLL	RRR	RRR
3	TLL	LTT	RRR	RRR	TTT	TTT	TTT
4	RTT	RRT	RTT	LTT	RTT	LTT	RTT
5	LLL	RTT	TLL	TLL	RRT	RTT	LTT
6	RRR	TLL	TTT	RRT	LTT	RRT	RRT
7	LTT	RTR	RRT	RTT	TLL	TLL	TLL
8	RTR	TTT	RTR	RTR	RTR	RTR	RTR

Table 30

Experiment 2 Ranking of Menu Structures for All Measures

Condition	Navigation Time	Selection Errors	Hesitation	Cursor Movement	Overall Preference	Equal Weight Score	Adjusted Weight Score
LLL	5	1	2	1	2	1	1
LTT	8	3	1	4	6	4	5
TTT	1	8	6	2	3	3	3
TLL	3	6	5	5	7	6	6
RRR	6	2	2	2	1	2	2
RRT	2	4	7	6	5	7	7
RTT	4	5	2	7	4	5	4
RTR	7	7	8	8	8	8	8

Table 31

Experiment 2 Correlation of Survey Measures

	Navigation Time	Selection Errors	Hesitation	Cursor Movement	Overall Preference	Adjusted Weight Score	Equal Weight Score
Navigation Time	1						
Selection Errors	-0.428571	1					
Hesitation	-0.421849	0.703082	1				
Cursor Movement	0.102517	0.467026	0.468326	1			
Overall Preference	0.190476	0.523809	0.508382	0.763189	1		
Adjusted Weight Score	0.047619	0.523809	0.681449	0.854316	0.904762	1	
Equal Weight Score	-0.047619	0.571428	0.703082	0.922661	0.857143	0.976190	1

Based on the data for correlation for all measures by rank, in Table 31, the following is a breakdown of all high significant correlations, positive trends, neutral to near neutral trends and negative trends. See Table 32 for a grouping of correlations.

Table 32

Breakdown of Experiment 2 dependent measure correlations

Significant high correlations:

- ☐ Hesitation-Selection Errors
- ☐ Adjusted Weight Score- Hesitation
- ☐ Survey-Cursor Movement
- ☐ Adjusted Weight Score - Cursor Movement
- ☐ Equal Weight Score - Cursor Movement
- ☐ Adjusted Weight Score –Survey
- ☐ Equal Weight Score -Survey
- ☐ Adjusted Weight Score - Equal Weight Score

Positive Trends:

- ☐ Cursor Movement-Selection
- ☐ Survey-Selection
- ☐ Adjusted Weight Score -Selection
- ☐ Equal Weight Score -Selection
- ☐ Cursor Movement-Hesitation
- ☐ Survey-Hesitation
- ☐ Adjusted Weight Score - Hesitation

Neutral to near neutral trends

- ☐ Cursor Movement-Navigation Time
- ☐ Survey- Navigation Time
- ☐ Adjusted Weight Score - Navigation Time

Negative trends:

- ☐ Selection- Navigation Time
 - ☐ Hesitation- Navigation Time
 - ☐ Equal Weight Score - Navigation Time
-

Navigation Time vs. Preference

A correlation of values and rank was performed with navigation time and preference to see if there is any correlation between the two measures. No significant correlation was found between navigation time and overall preference by rank. Refer to Table 33 for correlation by rank and Figure 64 for a graphical representation of each menu structure by rank.

A positive correlation was found between the two measures by value, however this correlation was not significantly high. Refer to Table 34 for a correlation by value and Figure 65 for a graphical representation of each menu structure by value.

Table 33

Experiment 2 Correlation of Navigation Time vs. Overall Preference by Rank

	<i>Overall Preference</i>	<i>Navigation Time</i>
Overall Preference	1	
Navigation Time	0.19047619	1

Figure 64. Experiment 2 navigation time vs. overall preference by rank.

Table 34

Experiment 2 Correlation of Navigation Time vs. Overall Preference by Value

	Overall Preference	Navigation Time
Overall Preference	1	
Navigation Time	0.405713931	1

Figure 65. Experiment 2 navigation time vs. overall preference by value.

EXPERIMENT 2: DISCUSSION

The second experiment was an exploratory study to determine the influence of a right side primary menu, compared to the better performing primary left and primary right menu structures from the first experiment (LLL, LTT, TTT, and TLL). The following is a discussion of each performance and preference measure to address the same hypotheses from the first experiment regarding primary menu location and the benefit for grouping secondary and tertiary menus together on the same plane.

Navigation Time

Viewing all conditions as a collection of individual menus schemes the best performing (fastest) structures were the LTT, RRT, and TLL menu structures. Each of top three fastest structures had a different primary menu. The LTT and TLL menu structures both split the primary menu from the secondary and tertiary menu levels. This suggests an advantage for splitting the secondary and tertiary menus from the primary menu.

The results the second exploratory study are consistent with the first experiment, whereby the LTT and TLL structures were also the fastest performing structures from the first experiment, and continue to be in this exploratory study. Additionally, the four menu conditions that were used in the first experiment rank in the same order in this second experiment, from best to worst: LTT, TLL, LLL, and TTT.

A primary left menu performed the fastest overall (L, mean = 106.25) compared to a primary right menu (R, mean = 114.09) and primary top menu (T, mean = 117.63). Splitting the primary menu from the secondary menu has an advantage in saving time (LTX, TLX, and RTX, mean = 105.51) over grouping primary and secondary menus on the same plane (LLX, TTX, and RRX, mean = 115.52). Little difference in navigation time was found between grouping the secondary and tertiary menus on the same plane (XLL, XTT, and XRR, mean = 112.48) than when secondary and tertiary menus were split (XRT and XTR = 114.62). However, within this secondary and tertiary grouping, there is an advantage to split the secondary and tertiary menus from the primary menu (LTT, TLL, and RTT, mean = 106.51) compared to retaining all menu levels on the same plane (LLL, TTT, and RRR (mean = 118.45).

These results suggest that the location of the primary menu is the dominant factor for navigation time, and the grouping of secondary and tertiary menus is significant, but less of a factor for navigation time. These two principles combine to predict the faster navigation times of the LTT, TLL, and RTT menu structures (see Table 21).

Hesitation

Viewing all conditions as a collection of individual menu schemes, hesitation, as with navigation, found the LTT menu structure have the least amount of hesitation over all other menu structures. The LLL, RRR, and RTT menu conditions were tied for second place with the same amount of hesitation.

These four menu structures are consistent for grouping secondary and tertiary menus together on the same plane. However, there is no clear advantage whether or not the primary menu should be grouped or split from the secondary and tertiary menu levels.

The four menu conditions that were used in the first experiment rank in a different order in this second experiment, from best to worst: LTT, LLL, TLL, and TTT. The LLL and TLL menu conditions swapped order compared to the first study.

Using a left primary menu also had the least amount of hesitation (L, mean = 0.13) compared to a primary top (T, mean = 0.28) or primary right (R, mean = 0.50) menus. Unlike navigation time, hesitation shows an advantage for grouping of primary and secondary menus (LLX, TTX, and RRX, mean = 0.28) over grouping of secondary and tertiary menus (XLL, XTT, and XRR, mean = 0.42). Hesitation was consistent with navigation time for grouping of secondary and tertiary menus on the same plane (XLL, XTT, and XRR, mean = 0.20) compared to splitting of secondary and tertiary menus (XRT and XTR, mean = 0.81). Additionally, splitting the secondary and tertiary menus from the primary menu (LTT, TLL, and RTT, mean = 0.17) had less hesitation compared to grouping all menu levels on the same plane (LLL, TTT, and RRR, mean = 0.23).

These results suggest grouping of secondary and tertiary menus on the same plane is a dominant factor to reduce hesitation followed by placing the

primary menu on the left. These two principles combine to predict the faster navigation times of the LTT, and LLL menu structures (see Table 22).

Cursor Movement

Viewing all conditions as a collection of individual menu schemes, the fewest cursor movements were found with the LLL, RRR, and TTT menu structures. All structures group all three levels on the same plane. This is an important finding for cursor movement that is consistent with the first experiment, where LLL and TTT had the least amount of cursor movement. Grouping all menus in the same plane, as discussed with the first study, has an advantage for less incorrect cursor movements to the incorrect plane since the cursor is already positioned on the plane one would need to navigate to for sub-levels.

Taking the grouping of all menus on the same plane out of the equation, the LTT and TLL menu structures were the next best performing conditions. These are similar structures, each grouping the secondary and tertiary menus and splitting the primary menu from secondary and tertiary menus.

RTR was found to significantly have the most amount of incorrect cursor movement. We believe the reason for higher cursor movement for this condition is due to the need to jump back and forth between planes. Participants may have had an expectancy that the next menu level be positioned on the same plane, only to have to recognize that the menu has “jumped” to another plane.

A primary left menu (L, mean = 0.47) and primary top menu (T, mean = 0.59) have an advantage over the primary right menu (R, mean = 1.33) to reduce

the number of cursor movements. Grouping primary and secondary menu levels on the same plane (LLX, TTX, and RRX, mean = 0.41) compared to splitting menus across two planes (LTX, TLX, and RTX, mean = 1.45) also reduced cursor movements to the wrong plane. Additionally, grouping secondary and tertiary menus on the same plane (XLL, XTT and XRR, mean = 0.64) had fewer cursor movements over splitting secondary and tertiary menus (XRT and XTR, mean = 1.78). However, unlike hesitation, cursor movements were greatly reduced when all menus were grouped on the same plane (LLL, TTT, and RRR, mean = 0.17) compared to splitting the secondary and tertiary menus from the primary menu (LTT, TLL, and RTT, mean = 1.13).

These results suggest grouping of secondary and tertiary menus on the same plane as a dominant factor to reduce incorrect cursor movements followed by placing the primary menu on the left side or at the top. These two principles combine to predict the faster navigation times of the LLL, TTT, and RRR menu structures (see Table 23).

Selection Errors

Viewing all conditions as a collection of individual menu schemes, the fewest selection errors were found with the LLL, RRR, and LTT menu structures. Each of these structures group the secondary and tertiary menu levels together on the same plane. However, the top two best performing (fewest selection errors) are structures that group all menus on the same plane. These findings

are fairly consistent with the cursor movement and hesitation findings. The LLL menu structure also performed well in the first experiment.

The TTT structure had significantly the largest number of selection errors compared to all other conditions. This may be due to the store category type (Toys) used for this menu structure. Some participants struggled to locate the correct link among the set of menus in this structure compared to other more familiar store types.

A primary left menu was found to perform better (L, mean = 0.18) compared to a primary top menu (T, mean = 0.58) and a primary right menu (R, mean = 1.39). Splitting the primary and secondary menus (LTX, TLX, and RTX, mean = 0.67) had little difference compared to grouping the primary and secondary menus on the same plane (XLL, XTT, and XRR, mean = 0.72). Similarly, no differences were found between grouping the secondary and tertiary menus on the same plane (XLL, XTT, and XRR, mean = 0.69) compared to splitting the secondary and tertiary menus on different planes (XRT and XTR, mean = 0.72). Finally, grouping the secondary and tertiary menus together split from the primary menu (LTT, TLL, and RTT, mean = 0.60) had little advantage over grouping all three menu levels on the same plane (LLL, TTT, and RRR, mean = 0.77).

These results suggest the dominant influence of a primary left menu. All other menu levels groups had little differences, yet the small advantages do

predict the LLL and RRR menu structures to have the fewest selection errors (see Table 24).

Overall Preference

Viewing all conditions as a collection of individual menu schemes, participants preferred grouping all menu levels on the same plane with all menus on the same plane, with the RRR, LLL, and TTT menus as the top three most preferred menu structures. This was a consistent finding from the first experiment, where the LLL and TTT menu structures were the most preferred over all other menu conditions.

Most participants commented on preferring retaining all menus together, finding it easier to search when all levels are grouped together since one does not have to focus to any other section of the page. Although participants were not screened for handedness, some left-handed and some right-handed participants used the mouse with their right hand. Some left-handed individuals commented on preferring all menus on the right despite the fact that they were left handed. Some of the comments made on the post interaction survey about grouping all menus were:

"All of the submenus are directly under the category instead of on a separate frame. So it's pretty quick to see." (RRR)

"I usually like things on the left since I'm left-handed, but having the menus on the right seemed to catch my eye quicker. I think the reason for this is because I'm using the mouse with my right hand, so moving the mouse all the way to the left of the screen would take more time and movement for me. Or seeing the menu from the top across the screen seemed to take too long to find what I was looking for." (RRR)

"I like to have all the information in one area all the time and having it at my right works best for me." (RRR)

"Menu on the left hand side of the screen is the easiest to see. I especially like when you open a link and several new links are listed right underneath this." (LLL)

"To me, the first thing that I look at is left column of this page, so I would want the links to be on the left side." (LLL)

"All in one area. Tendency to focus on the left being left handed." (LLL)

"It is easiest for me to scroll from left to right when looking or following directions." (LLL)

"It is clear and the view does not have to travel back and forth for different menus." (TTT)

"You don't have to go searching around the page looking for the next link. It's right there. Also, seems to stand out more when page initially loads." (TTT)

See Appendix O for all results of the survey summary for Experiment 2.

Grouping all menus on the right allows the mouse to be closer to the scroll bar at all times when navigating through menus. Nielsen (1999) and others have viewed this as an advantage for right side menu structures.

Unlike all other performance measures, the next most favored condition was the RTT menu conditions, rather than the LTT condition. This again suggests users' preference for starting on the right hand side of the screen rather than the left.

A primary left menu was found to perform better (L, mean = 20.09) compared to a primary top menu (T, mean = 22.22) and a primary right menu (R, mean = 23.84). Grouping the primary and secondary menus on the same plane (LLX, TTX, and RRX, mean = 18.67) was preferred compared to splitting the primary and secondary menus (LTX, TLX, and RTX, mean = 26.33). There was little difference found between grouping the secondary and tertiary menus on the

same plane (XLL, XTT, and XRR, mean = 30.47) compared to splitting the secondary and tertiary menus on different planes (XRT and XTR, mean = 29.62). Finally, grouping all three menu levels on the same plane (LLL, TTT, and RRR, mean = 17.19) was more preferred compared to grouping the secondary and tertiary menus together split from the primary menu (LTT, TLL, and RTT, mean = 23.44).

These results suggest the grouping of secondary and tertiary menus together on the same plane to be the dominant factor that influences participant preference. Additionally, grouping all menus on the same plane was a secondary dominant factor. These two principles combine to predict preference for the RRR and TTT menu structures (see Table 25).

Survey Measures

Participants were consistent in their ranking of subjective measures for fastest to complete, easiest to navigate, fewest errors, most intuitive and overall preference across all menu structures, ranking RRR and TTT as the more preferred structures.

Overall Score

The equal weight and adjusted weight overall scores produce similar results with only two conditions swapping their ranking position. Combining performance and preference data, LLL, RRR, and TTT menu structures, all of which group all on the same plane were found to be the best structures from the

exploratory study. The vertical left or right with all menus down the page appear to be better than all menus horizontally across the top of the screen.

Removing LLL, RRR, and TTT from the picture, we see the LTT and RTT menu structures as the next best structures across all measures. Note that these structures both start with a vertical primary menu with secondary and tertiary menus grouped at the top. There was no difference in score for overall equal weight scores and there was no difference between these two conditions for the overall adjusted weight scores (RTT = 4.54, LTT = 4.56). Looking across all measures, LTT performed better than RTT for navigation time, selection errors, hesitation, and cursor movement. The only measure LTT did not score better was in overall preference. We find that these menu conditions could be used interchangeably, yet there are some advantages for using a primary left menu over a primary right menu.

Navigation Time vs. Preference

There is no consistency between the performance navigation time data and overall preference survey data. Even within the performance measures collected, different measures vary in their order of results. A primary menu split from secondary and tertiary menus grouped on the same plane (LTT, RTT) performed better for navigation time, whereas grouping all menu levels on the same plane was preferred over any split of menu levels. This is yet another example of the performance-preference dissociation (Andre & Wickens, 1995).

Summary

There is no structure that both consistently performed well and was preferred across all performance and preference measures collected. A primary left or right menu is favored for most measures, as well as a grouping of secondary and tertiary menu levels on the same plane. Navigation time shows a benefit for splitting the secondary and tertiary menus from the primary menu, however all other performance and preference measures favor grouping all menu levels on the same plane.

Overall, the LLL and RRR menu conditions came out as the best performing and most preferred. Grouping all menu levels on the same plane (LLL, RRR) had advantages across all measures except navigation time. However, separating the secondary and tertiary menus from the primary menu (LTT, RTT) has an advantage in task navigation time.

Extracting those conditions that group all measures together we found the LTT and RTT menu structures as the next best menu structures to use for their faster navigation time and better use of screen real estate over all other menu conditions. LTT consistently performed well across a number of performance measures, yet was not as preferred compared to RTT. Participants have expressed a preference for starting with a primary menu on the right, which is an advantage for RTT.

From our exploratory study of a primary right menu, although LLL, TTT, LTT, and RTT have advantages and disadvantages in different measures there is

still no clear winner at this time. A further analysis for using right-handed menus is needed to determine how much of an advantage a primary right menu has over a primary left menu.

GENERAL DISCUSSION

Performance Preference Dissociation

The results of this study replicated a well-documented and common phenomenon, known as the performance preference dissociation (Andre and Wickens, 1995). Often, those menu structures that performed best were not the same menu structures that were preferred by participants. In this study the variance in real-world exposure to some of the menu hierarchies may have influenced the participants' preferences, in addition to the fact that it was difficult to gauge one's own performance during the session.

Primary Menu Location

The results of this study strongly suggest a primary left menu benefit, in terms of both performance and preference, over primary top menus. This was consistent with prior primary menu studies (Backs, 1987; Bernard, 2001; Gathman, Lee and Nader, 1998; Norman, 1987).

A primary left-hand menu presents all links vertically down the page. This may be easier to visually search and locate an item when information is presented in a column vertically down the page compared to horizontally across the page. In prior studies participants have preferred and had an expectancy for left menu navigation (Bernard, 2001; Gathman, Lee and Nader, 1998). Also, our survey of current web menu design showed common use for the left side in menu design. Therefore it is a familiar and perhaps comfortable starting location.

Finally, given that we read from left to right it is natural to start on the left-hand portion of the screen and work our way in towards the right (Flemming, 1998).

From the second exploratory study we saw preference for a primary right menu, suggesting a need to further research this novel menu structure. This may be due to the greater ease of scanning a vertical array of links relative to a horizontal array. Although right-side menus are not common on the Web, there may be some advantages for its use as a primary menu location. One example is the proximity of this location to the scroll bar, both being on the right side of the screen. Although scroll was rarely required for this study's navigation tasks, the presence of the menus next to the scroll bar may have had an impact subjectively on user's preference.

Use of Right Menus

A right-hand menu has many benefits. One benefit is the location near the scroll bar. Keeping at least two menus on the right-hand side may require less scrolling back and forth across the screen compared to a structure that uses left and top menus, whereby one would have to move over to the right side of the page to scroll and move back to another section of the screen to return to the menus.

Another benefit for right-hand menu structures comes from the issue of handedness. The majority of population is right-handed. Even those who are left-handed tend to use right hand when using a computer mouse. Using the right

hand to mouse lines up with the right justified scroll bar, requiring less movement of the eyes and hands for navigating through right-hand menus.

Primary-Tertiary Menu Relationship

Using a condition where the primary and tertiary menus are on the same plane (LTL, TLT, RTR) should never be used for a menu design. Such menu structures require too much mouse movement back and forth across the page, and impact one's eye movement making it difficult to focus on the overall structure. This not only takes longer to navigate a site with such a structure, but also is found to be a source of frustration or annoyance. Many participants commented that these layouts were "confusing," stating they shouldn't have to go back to a location where they just started for the third menu level.

Primary-Secondary vs. Secondary-Tertiary Menu Grouping

The best performing menu structures from both studies had at least two menus grouped on the same plane (LLL, LTT, RRR, RTT, TTT, and TLL). However, grouping secondary and tertiary levels together performed better and was more preferred over menu structures that group the primary and secondary menu levels together. Grouping of at least two menus together allows the relationship of menus to stay in tact, rather than forcing users to bounce around the screen determining the relationship and order of menus across different planes of the screen. The secondary and tertiary menus typically have a closer relationship to one another than primary and secondary menus, therefore

grouping of these menus together allows for easier navigation, search and processing of information.

Secondary-Tertiary: Split vs. Same Primary Location

We have already concluded that grouping the secondary and tertiary menus together on the same plane is better than grouping of primary and secondary menus. However, the question then remains, should the secondary and tertiary menus be placed on the same plane as the primary (LLL, RRR) or on an alternative plane (LTT, RTT) from the primary menu?

The preference for grouping all levels on the same plane shows the simplicity participants would like to have when navigating through a site. Participants find it easier to position all menus together. In their post-interaction surveys many participants expressed an interest in keeping all menus on the same plane, in part due to design. Less effort is required when all menus are on the same link. There is no doubt where to move next on the screen to locate a menu, compared to when the menus are split across multiple planes. Additionally hesitation, selection errors and incorrect cursor movements all are reduced when all levels are grouped on a single plane. This is a tradeoff for placing all menus on the same plane. To navigate the menu the cursor only need to stay in one plane, compared to moving back and forth between multiple planes.

Looking only at the performance and preference data from this study one would assume keeping all levels on the same plane would be the best condition

to implement. As much as there are some benefits with these conditions, there are also some costs.

The one major benefit for an all-grouped condition is they result in less hesitation, when the secondary and tertiary levels are grouped together with the primary, since the mouse is already located on the same plane. This adds an element of consistency, resulting in less hesitation and incorrect cursor movements. There is no questioning at any point in time where one's menu will appear on the screen, compared to split menus where users cannot guess as to the location until it appears on the screen.

However, the costs associated with such a design are that it may require more attention than when menus are split across multiple planes. It may take longer to process all the menus depending on the design and layout of the hierarchy of menus. Time to scan and scroll through menus may increase as a result of grouping all menus together on the same plane, as demonstrated by the longer navigation times associated with such menu structures.

As a developer, making use of all available screen real estate is an important task. Placing all menus on the same plane (LLL, RRR, and TTT) may result in excessive scrolling with a large number of menu links, depending on the content of the site or the font size used. Ideally as many links as possible should be viewed on the screen to provide more context as to all available options, yet a design with numerous links all on the same plane would require small font sizes in order to place all links on the same plane, resulting in poor readability.

Just as with placing all menus on the same plane, the alternative design, of placing secondary and tertiary menus on an alternative plane from the primary menu, also has some benefits and costs associated with its menu design.

The major benefit for splitting these menus from the primary is that it makes use of more screen real estate. As a developer, using all available screen real estate is critical. Additionally, less scrolling is required since fewer links are grouped on any one plane. From observations of over 20 or more usability tests in the last three years (2000-2003) it is often the case that users will select a primary menu link and spend a majority of their time navigating between the secondary and tertiary menus. Therefore, attention is placed on the deeper menus rather than the starting menu.

Another benefit with this design is there is less information to process in a single plane by separating the primary menu from sub levels. By placing the primary menu on a separate plane, this removes the primary menu from distracting from the information available in the secondary and tertiary menus. Users can ignore the primary menu for the time being and keep their attention on only two menu levels rather than three. The addition of the third menu adds more complexity and more information to keep track of while interacting with a site.

One of the costs associated with a split-grouped design (LTT, RTT) is there is no consistency for where the all menus are placed. Only until one navigates through to the tertiary menu level, seeing how the menu hierarchy is presented on the screen, can one finally comprehend the design layout that has

been implemented. Such menu structures may take longer for one to gather a schema of the layout compared to those that group all levels on the same plane.

Recommended Three-Level Menu Structure(s)

It may be that depending on the nature of a web site and the amount of content required one may benefit more for all levels grouped together compared to the split design. However, when more information needs to be presented on screen, and one needs to make use of all screen real estate, splitting the primary menu from all other menus should be implemented.

The context, target audience and content of the site may influence the best menu structure to select when developing a site. A menu structure that groups all menus on the left (LLL) or right (RRR) should be used when the number of links associated with any given level are limited to five links. Considering that most sites tend to have a minimum of three primary menus (in fact the average may be more), our view is that 5 links per level is likely to result in more scrolling, which users may find frustrating and unappealing. Additionally more links means more information to process at a time and potentially more clutter, making it more difficult to process and retrieve information. We recommend the LLL and RRR structures when the content of the menus may require more attention to navigating between primary menus rather than focusing more on the destination link (tertiary menu level).

Splitting the primary menu on the left or right from the secondary and tertiary menus has more practical implications and is used for a site where the

audience focuses on a comparison of destination links (tertiary menu level) rather than jumping between primary levels. An example of this would be an electronics store. Users start with a goal to find a particular product or do a comparison of similar products, which relate to the destination links (brand names, features etc) more than the primary menus (electronic category). Separating the primary menu from the secondary and tertiary can allow the focus to be on the comparison of the available destinations rather than focusing on the broader topic of interest (primary menu level).

Limitations

There are a number of limitations associated with our studies, to include: 1) directed behavior, 2) little reading associated with tasks, 3) the simplistic menu design, and 4) minimal use of scroll bars.

In order to maintain consistency in the order of tasks executed, participants were instructed to make specific target selections, resulting in directed behavior for navigation of menus. Rather than a natural free-form interaction with each web site, participants were forced to navigate a particular path under strict instructions to read the task once to themselves silently, then once out loud before moving their cursor. This is not a natural web browsing interaction that normally occurs in a natural environment and therefore may have some influence on the performance results.

Another limitation of this study is the design of each web site. Each site provided a menu with no other content appearing in the center of the page until

the final target destination page was selected. This results in less information on the screen for users to take in and process compared to a fully developed web site with numerous banner ads, advertisements, multiple colors, fonts and text sizes to process. We chose to use a simple design that allowed us to study what happens when no other distractions are present on screen. Navigation time, cursor movement, selection errors and hesitation are most likely significantly lower compared to what could occur given a fully developed web site with more information to process and distractions to influence one's online interaction with the menu structure.

In order to gather navigation time, the Ergobrowser™ web browser was used to aid in recording navigation time, requiring participants to manage controls for starting and stopping their navigation time. This was limiting in that first, it allowed participants to be more aware of what was taking place during their session, since additional buttons had to be selected before searching for the next target item. The browser was seen as a "hassle" in the interaction process taking the focus away from web browsing and onto controlling the browser.

The lack of scrolling is another limitation of this study. Although a scroll bar was present on screen, participants required minimal, if no scrolling, when interacting with each menu structure. By not using the scroll bar this study did not test the true assumption of a right-hand menu, believed to be faster for navigating to another menu level.

The design of the study is another limitation. The first study used a full factorial of design with the top and left side planes. However, the second study was a non-factorial design. Not all possible menu layouts were used. Those sites using a primary right-hand menu were used in combination with the top rather than testing those that use a primary top menu in conjunction with right hand menus.

Other limitations may exist due to the nature of the participants used in this study. Only those individuals with web experience, self-rated as intermediate web and computer users were used for this study. This eliminated other populations, such as novice and expert web users, non-web shoppers and power web-shoppers. Additionally, the mean age for this study was younger due to using undergraduate college students. This study did not look at differences among age populations for web site performance and preference.

Future Research

Continued research in menu design is necessary to determine which menu structure is best both in its performance and preference among all user types, under more realistic conditions and adding more design to the menu structures. From this study a number of important issues arose that still need to be addressed including menu design, use of color, interactive menus, menu terminology, the impact of a scroll bar and the role of handedness in menu design and navigation.

The menu layouts that were created for this study did not incorporate design methods, such as tabs, buttons or other graphical means for displaying a menu link. In addition, menus were not animated, such as incorporating pop-ups or rollovers that are common web design techniques for menu design by some developers. Further research is needed to determine which combination of placement, color(s), interaction method and design provide an optimal menu design (fastest to navigate, most appealing, least errors etc.).

Another area of interest that may be pursued is examining menu terminology and its impact on menu navigation. The order of terms used to describe a menu and the location of menus may have an impact as to how well one comprehends and navigates a web site's structure. For example, in the case of an Electronics web site there are two alternative methods for presenting menu terminology. One may choose to first present the list of brand names followed by electronic types (e.g., SONY > VCR's) or the reverse, presenting electronic types and then brand names (VCR's > SONY). Depending on the order selected and placement of menus one may have a clearer understanding of the web site layout.

The context of a web site could play a role in which layout is ideal for navigation. There are different target audiences for a shopping web site compared to a corporate web site. Each audience has a different set of requirements and goals and may therefore benefit from a different menu layout.

Further research should determine whether or not there is a need for different menu schemes for different web types.

Future research should determine exactly how much of a difference the right side plays over the left or top. Part of this may come from the location of the scroll bar next to a right-hand menu. Related to this topic may be the issue of handedness. Does it make a difference to be right or left-handed using a primary left, right or top menu? And does being right-handed and have a right-hand menu next to the scroll bar enhance one's navigation compared to those who are left-handed?

CONCLUSION

The objective of these studies was to determine the relative importance of menu location and grouping in the context of a 3-tier menu design for e-commerce sites. From the first study we learned that a primary left menu is advantageous over a primary top menu. Additionally, grouping secondary and tertiary menus either together on the left (LLL), or separate at the top from the primary left menu (LTT), resulted in the better performing and preferred menu structures.

Our second study was more exploratory in nature. Those menu structures that grouped secondary and tertiary levels together performed better and were preferred over those that used alternative groupings. Further, the primary right-hand menu design shows promise for future menu design with participants preferring primary right menus over most other menu structures. However,

further research on right-hand menu structures is needed to learn how much of a benefit it has over a left-hand menu scheme.

An argument has been made for splitting the secondary and tertiary menus onto a different plane from the primary level (LTT, RTT). Using a left or right primary menu with secondary and tertiary menus grouped together at the top performed well and had good performance ratings. There are benefits for these designs over grouping all menu levels on the same plane, such as reduced visual clutter and increased flexibility in the use of available screen real estate. While much was learned in the present studies, there is a need to further evaluate three-level menu designs to determine the confluence of factors that will yield optimal performance and preference ratings.

Based on our findings, we recommend the LLL and RRR menu structures (all levels grouped on a single plane) when the content of the menus may require more attention to navigation between primary menus rather than focusing more on the destination content (tertiary menu level). We find the use of LTT and RTT (splitting the primary menu on the left or right from the secondary and tertiary menus) to be a more practical design that should be used when the user needs to focus on the comparison of destination content/products (tertiary menu level).

The results of these studies have important implications for the design of multi-level web site menu structures and represent a first-step towards providing empirical-based guidelines to site designers.

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Appendix A

Sites Surveyed by Menu Structure

Menu Navigation Structures Surveyed – E-commerce Sites								
TTT	LLL	LTT	TLL	LLT	LTL	TTL	TLT	Other
<ul style="list-style-type: none"> • Apple • Noosh • Quantum • Siebel Systems • Adobe Systems Inc 	<ul style="list-style-type: none"> • AMD • BofA • ESPN • Target • Corning • Legato • Netscape • Oracle Corp • Gateway Inc 	<ul style="list-style-type: none"> • MyGazoo • E.piphany 	<ul style="list-style-type: none"> • Ariba • Escrow • BEA • AMEX • b2bnow • Enron • McDonalds • Chevron • McAfee • Home Depot • Lucent • Webvan • Fedex • Good Year • Sun • Staples • Progressive • Egain • Starbucks • Fogdog • Chordiant Software • Hewlett Packard • Microsoft • Agilent Technologies • Vividence Corp • Iplanet • Intira Corp • Broadvision • Netraker • WebTV • Documentum • Nortel Networks 			<ul style="list-style-type: none"> • Dell • NBC • GE • CBS 		<ul style="list-style-type: none"> • Kmart (TRR) • Beckman Coulter (TRL) • Macromedia (TRR) • Arthur Anderson (TLR) • Proctor & Gamble (TLC)
N=5	N=9	N=2	N=32	N=0	N=0	N=4	N=0	N=5 Total=57

Menu Navigation Structures Surveyed – Human Factors Site								
TTT	LLL	LTT	TLL	LLT	LTL	TTL	TLT	Other
	<ul style="list-style-type: none"> • Sammie 	<ul style="list-style-type: none"> • Thought Ware Solutions, Inc • Addwise 	<ul style="list-style-type: none"> • MSDN • Carnegie Mellon • Mouse Works Media 		<ul style="list-style-type: none"> • Visual Produce 	<ul style="list-style-type: none"> • IAA • Fischer Consulting Services 		<ul style="list-style-type: none"> • Ignition (RRL) • Imagesmith (TRR) • Cognetics Corporation (TTR)
N=0	N=1	N=2	N=3	N=0	N=1	N=2	N=0	N=3
								Total=12

Menu Navigation Structures Surveyed – All Sites									
TTT	LLL	LTT	TLL	LLT	LTL	TTL	TLT	Other	Total
TOTAL =5	TOTAL =10	TOTAL =4	TOTAL =35	TOTAL =0	TOTAL =1	TOTAL =6	TOTAL =0	TOTAL =8	TOTAL =69

E-commerce Sites Surveyed:

1. Apple: <http://www.apple.com> TTT
2. Dell: <http://www.dell.com/us/en/dhs/topics/handheld.htm> TTL
3. AMD: <http://www.amd.com> LLL
4. Ariba: <http://www.ariba.com> TLL
5. Arthur Anderson
<http://www.arthurandersen.com/website.nsf/content/MarketOfferings?OpenDocument> TLR-Other
6. Escrow :
http://www.escrow.com/solutions/transaction_settlement/index.html
TLL
7. BEA: <http://www.bea.com/customers/weblogic/server.shtml> TLL
8. Noosh: <http://www.noosh.com> TTT
9. American Express:
http://home5.americanexpress.com/merchant/learn/learn_default.asp?learn_body=learn_default&merch_home=learn_cardbenefits TLL
10. Enron: <http://www4.enron.com/corp/ourservices/ets.html> TLL
11. Bank of America:
http://corp.bankofamerica.com/cap_markets/cm_europe_middle_east_afric.html LLL
12. B2bnow.com: <http://www.b2bnow.com/businesscenter/>
13. Proctor & Gamble <http://www.pg.com> TLC-Other
14. McDonalds
<http://mcdonalds.com/corporate/info/history/history2/index.html> TLL
15. Chevron <http://www.chevron.com/> TLL
16. ESPN <http://espn.go.com/> LLL

17. NBC <http://www.nbc.com> TTL
18. CBS Sports <http://cbs.sportsline.com/nhl/> TTL
19. McAfee <http://www.mcafee.com> TLL
20. Mygazoo.com LTT
21. Home depot <http://homedepot.com/> TLL
22. Kmart <http://www.kmart.com> TRR
23. Target <http://www.target.com> LLL
24. Lucent: <http://www.lucent.com> TLL
25. Webvan: <http://www.webvan.com> TLL
26. Fedex. <http://www.fedex.com> TLL
27. GoodYear <http://www.goodyear.com> TLL
28. Sun T(drop down) <http://www.sun.com> LLL
29. Staples www.staples.com TLL
30. Quantum: <http://www.quantum.com/products/dlt/dlftape.htm> TTT
31. Corning:
http://www.corning.com/inside_corning/news_media/communications_library/index.asp LLL
32. Progressive <http://www.progressive.com> TLL
33. Legato <http://www.legato.com/services/vartraining/schedules/> LLL
34. Egain: <http://www.egain.com> TLL
35. Starbucks: <http://www.starbucks.com> TLL
36. Fogdog: <http://www.fogdog.com> TLL
37. E.piphany <http://www.epiphany.com/> LTT

38. Beckman Coulter:
<http://www.beckman.com/coulter/Cytometry/altra/forfluor.asp> Other
39. Chordiant Software <http://www.chordiant.com/news/industry.html> TLL
40. Hewlett packard : <http://www.hp.com/desktops/products/accessories/>
TLL
41. Macromedia <http://www.macromedia.com/> Other (TRR)
42. Netscape:
<http://personalfinance.netscape.com/finance/investing/stockresearch.tmpl> LLL
43. Microsoft , TLL <http://microsoft.com/ms.htm>
44. Agilent Technologies http://www.twsinc.com/user_testing.htm TLL
45. Vividence Corp
<http://www.vividence.com/public/Solutions/our+clients/testimonials.htm>
TLL
46. IPlanet
http://iplanet.com/products/iplanet_sellerxpert/home_2_1_1c.html TLL
47. Intira Corp <http://www.intira.com/home/netsourcing/integrated/network-infrastructure.html> TLL
48. Siebel Systems <http://www.siebel.com/eauction/index.html> TTT (pop-out menus)
49. Gateway Inc.
<http://www.gateway.com/consumer/expressguide/500to1000.shtml> LLL
50. Oracle Corporation
<http://www.oracle.com/ip/solve/performance/index.html?speed.html>
LLL
51. Broadvision
http://www.broadvision.com/OneToOne/SessionMgr/products/features.jsp?BV_SessionID=NNNN0740859667.0985905223NNNN&BV_EngineID=calkhcehhhlbfmdmckgcfhhclf.0&product=Business+Commerce&channelName=Business+Commerce&channelRuleset=Products+Channel

s&programName=Features&programRuleset=Business+Commerce+P
rograms TTL

- 52. Adobe Systems Inc. <http://www.adobe.com/motion/columns/main.html> TTT
- 53. Netraker: <http://www.netraker.com/nrinfo/solutions/b2b/executive.asp>
TLL
- 54. GE <http://www.gepolymerland.com/design/partners.html> TTL
- 55. WebTV <http://www.webtv.com/products/personaltv/index.html> TLL
- 56. Nortel Networks
<http://www.nortelnetworks.com/ecommerce/distributors/index.html> TLL
- 57. Documentum
<http://www.documentum.com/services/consulting/index.html> TLL

Human Factors Sites Surveyed:

1. Sammie CAD:
http://www.lboro.ac.uk/departments/cd/docs_dandt/research/ergonomics/sammie/home.htm pop-out LLL
2. MSDN <http://msdn.microsoft.com/default.asp> TLL
3. Carnegie Mellon Software Engineering Institute
<http://www.sei.cmu.edu/sema/courses.htm> TLL
4. ThoughtWare Solutions, Inc.
http://www.twsinc.com/user_testing.htm LL, then LTT
5. The Usability Group <http://www.usability.com/> Other
6. Ignition <http://www.ignitiondesign.com/> Other (RRL)
7. Imagesmith
http://www.imagesmith.com/solutions/sol_webapps_epson.html
Other TRR
8. Cognetics Corporation
http://www.cognetics.com/services/ui_design.html TTR
9. Addwise <http://www.addwise.com/htmls/usability.htm> LTT
10. Interface Analysis Associates <http://www.interface-analysis.com> TTL
11. Visual Produce
http://www.visualproduce.com/vp_portfolio/alphablox01.html LTL
12. Fischer Consulting Services
<http://www.fischerconsult.com/services.htm> TTL

Appendix B

Menu Structure Interaction Order – Experiment 1

		Menu Structure Order															
Participant Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	LTL	LTT	TLT	TTT	LLT	TTL	TLL	LLL	LLL	TLL	TTL	LLT	TTT	TLT	LTT	LTL
	2	LTT	TLT	TTT	LLT	TTL	TLL	LLL	LTL	LTL	LLL	TLL	TTL	LLT	TTT	TLT	LTT
	3	TLT	TTT	LLT	TTL	TLL	LLL	LTL	LTT	LTT	LTL	LLL	TLL	TTL	LLT	TTT	TLT
	4	TTT	LLT	TTL	TLL	LLL	LTL	LTT	TLT	TLT	LTT	LTL	LLL	TLL	TTL	LLT	TTT
	5	LLT	TTL	TLL	LLL	LTL	LTT	TLT	TTT	TTT	TLT	LTT	LTL	LLL	TLL	TTL	LLT
	6	TTL	TLL	LLL	LTL	LTT	TLT	TTT	LLT	LLT	TTT	TLT	LTT	LTL	LLL	TLL	TTL
	7	TLL	LLL	LTL	LTT	TLT	TTT	LLT	TTL	TTL	LLT	TTT	TLT	LTT	LTL	LLL	TLL
	8	LLL	LTL	LTT	TLT	TTT	LLT	TTL	TLL	TLL	TTL	LLT	TTT	TLT	LTT	LTL	LLL
	9	LTL	LTT	TLT	TTT	LLT	TTL	TLL	LLL	LLL	TLL	TTL	LLT	TTT	TLT	LTT	LTL
	10	LTT	TLT	TTT	LLT	TTL	TLL	LLL	LTL	LTL	LLL	TLL	TTL	LLT	TTT	TLT	LTT
	11	TLT	TTT	LLT	TTL	TLL	LLL	LTL	LTT	LTT	LTL	LLL	TLL	TTL	LLT	TTT	TLT
	12	TTT	LLT	TTL	TLL	LLL	LTL	LTT	TLT	TLT	LTT	LTL	LLL	TLL	TTL	LLT	TTT
	13	LLT	TTL	TLL	LLL	LTL	LTT	TLT	TTT	TTT	TLT	LTT	LTL	LLL	TLL	TTL	LLT
	14	TTL	TLL	LLL	LTL	LTT	TLT	TTT	LLT	LLT	TTT	TLT	LTT	LTL	LLL	TLL	TTL
	15	TLL	LLL	LTL	LTT	TLT	TTT	LLT	TTL	TTL	LLT	TTT	TLT	LTT	LTL	LLL	TLL
	16	LLL	LTL	LTT	TLT	TTT	LLT	TTL	TLL	TLL	TTL	LLT	TTT	TLT	LTT	LTL	LLL

LLL: Clothing

LLT: Electronics

LTT: Sports

LTL: Clothing

TTT: Toys

TTL: Books

TLL: Movies

TLT: Furniture

Appendix C

Participant Screener

The desired demographic for this study are males and females, ages of 18 and older who use the web on a daily basis. Participants will have used the web a minimum of one year and should consistently use the web on a daily basis. In addition, participants should have experience purchasing items on the web, such as apparel, electronics and music within six months from the date of testing.

- ☐ How long have you been using a computer? *If 2-8 years continue, else terminate.*
- ☐ How long have you been using the web? *If 1 year or more continue, else terminate.*
- ☐ How would you rate your level of experience (novice, intermediate, expert)? *If intermediate or expert continue, else terminate.*
- ☐ How often do you surf the web? *If 5-7 days per week continue, else terminate.*
- ☐ Have you ever purchased items from the web before? *If yes continue, else terminate.*
- ☐ What type of items have you purchased? *If apparel, electronics, computers, music, etc continue, else terminate.*
- ☐ What is your occupation? *If web developers or designers terminate, else continue.*
- ☐ How old are you? *If less than 18 terminate, else continue.*

Appendix D

SJSU IRB Approval Letter

San José State
UNIVERSITY

**Office of the Academic
Vice President**
**Associate Vice President
Graduate Studies and Research**

One Washington Square
San Jose, CA 95192-0025
Voice: 408-283-7500
Fax: 408-924-2477
E-mail: gsr@sjsu.sjsu.edu
<http://www.sjsu.edu>

To: Jennifer Kingsburg
5214 Vera Lane
San Jose, CA 95111

From: Nabil Ibrahim,
AVP, Graduate Studies & Research

Date: October 26, 2001

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

"A Comparison of Three-Level Menu Navigation Schemes for the Web."

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Nabil Ibrahim, Ph.D. immediately. Injury includes but is not limited to bodily harm, psychological trauma, and release of potentially damaging personal information. This approval for the human subjects portion of your project is in effect for one year, and data collection beyond October 25, 2002 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services that the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.

The California State University:
Chico, Colusa, Colusa, Colusa, Colusa
Bakersfield, Channel Islands, Chico
Dominguez Hills, Fresno, Fullerton,
Hayward, Humboldt, Long Beach,
Los Angeles, Maritime Academy,
Monterey Bay, Northridge, Pomona,
Sacramento, San Bernardino, San Diego,
San Francisco, San Jose, San Luis Obispo,
San Marcos, Sonoma, Stanislaus

Appendix E

Stimuli Web Site Menu Levels

LLL: Computers

- PC's (*Primary Level*)
 - Desktops (*Secondary Level*)
 - Apple (*Tertiary Level*)
 - IBM
 - Compaq
 - HP
 - Notebooks
 - Apple
 - IBM
 - SONY
 - Dell
 - Home Office
 - Compaq
 - Gateway
 - HP
 - IBM
 - Multimedia
 - MAC
 - IBM
 - Dell
 - HP
- Printers & Scanners
 - Inkjet Printer
 - Canon
 - Epson
 - HP
 - Lexmark
 - Laser Printer
 - Canon
 - Epson
 - HP
 - Lexmark
 - Scanners
 - HP
 - Epson
 - Umax
 - Canon

- Accessories
 - Cartridges
 - Cleaning Supplies
 - Cables
 - Miscellaneous
- Monitors
 - IBM
 - 15"
 - 17"
 - 19"
 - 21"
 - NEC
 - 15"
 - 17"
 - 19"
 - 21"
 - View Sonic
 - 15"
 - 17"
 - 19"
 - 21"
 - Philips
 - 15"
 - 17"
 - 19"
 - 21"
- Peripherals
 - Mice
 - Optical
 - Ergonomic
 - Scroll Wheel
 - Track Ball
 - Keyboards
 - Standard
 - Ergonomic
 - Split
 - Trays
 - Joysticks
 - Car Steering
 - Throttle Stick
 - Pad
 - Miscellaneous

- Drives
 - CD-ROM
 - DVD
 - CD Writer
 - Zip Drive
- Software
 - Office
 - Word Processing
 - Spreadsheets
 - Address Book
 - Financial Planning
 - Games
 - Action
 - Adventure
 - TV
 - Sports
 - Educational
 - Math
 - Science
 - Reference
 - Language
 - Graphics & Drawing
 - Drawing
 - Animation
 - Web Authoring
 - Photo Editing

LLT/RTR: Electronics

- Home Theater (*Primary Level*)
 - DVD (*Secondary Level*)
 - JVC (*Tertiary Level*)
 - Panasonic
 - RCA
 - Toshiba
 - TV
 - RCA
 - Sony
 - Mitsubishi
 - Toshiba
 - VCR
 - JVC
 - Panasonic
 - RCA
 - Toshiba
 - Camcorders
 - Canon
 - JVC
 - Panasonic
 - SONY
- Cameras
 - Digital
 - Olympus
 - Canon
 - Kodak
 - Fuji
 - 35mm
 - Canon
 - Olympus
 - Minolta
 - Kodak
 - Single Use
 - Polaroid
 - Kodak
 - Fuji
 - Wedding
 - Accessories
 - Carrying Case
 - Lenses
 - Film
 - Tripods

- PDA & Handhelds
 - Pocket PC PDAs
 - Palm
 - Sharp
 - Handspring
 - HP
 - Ebook
 - Franklin
 - RCA
 - Blackberry
 - Compaq
 - Colored Screens
 - Palm
 - Sharp
 - Handspring
 - HP
 - Accessories
 - Stylus
 - Carry Case
 - Cradle
 - Screen Protectors
- Telecommunications
 - Cell Phones
 - Nokia
 - Motorola
 - Sprint
 - Nextel
 - Cordless Phones
 - GE
 - AT&T
 - Southwest Bell
 - Casio
 - Pager
 - One Way
 - Two Way
 - Answering Machine
 - AT&T
 - GE
 - Panasonic
 - Casio
- Portable Music
 - Walkman
 - Aiwa

- Sony
 - Panasonic
 - Coby
- CD
 - Aiwa
 - Sony
 - Panasonic
 - Philips
- MP3
 - Sony
 - Rio
 - RCA
 - Samsung
- Radios
 - Sony
 - Samsung
 - Philips
 - RCA

LTT: Sports

- Basketball (*Primary Level*)
 - Balls (*Secondary Level*)
 - Official Size (*Tertiary Level*)
 - Intermediate Size
 - Junior/Mini Size
 - Pumps
 - Jerseys
 - NBA
 - NCAA
 - Customized
 - Practice
 - Shorts
 - Men's
 - Women's
 - Boy's
 - Girls
 - Warm-up Gear
 - Shorts
 - Sweatshirts
 - T-Shirts
 - Tanks
- Football
 - Balls
 - Office
 - Recreational
 - Youth
 - Foam
 - Pads
 - Arm/Hand/Elbow
 - Hip/Tailbone
 - Rib
 - Shoulder
 - Jerseys
 - NFL
 - NCAA
 - Customized
 - Practice
 - Helmets
 - Pro
 - College
 - Youth
 - Other

- Baseball
 - Hats
 - Major League
 - Customized
 - Fitted
 - Other
 - Pants
 - Men's
 - Women's
 - Boys
 - Girls
 - Bags
 - Bat
 - Team
 - Equipment
 - Ball
 - Balls
 - Pro
 - Senior
 - Youth
 - Training
- Hockey
 - Sticks
 - Adult
 - Kids
 - Goalie
 - Shaft Only
 - Pucks
 - Franklin Pro
 - Sun Hockey
 - IDS
 - Mylec
 - Helmets
 - Adults
 - Kids
 - Goalie
 - Other
 - Pads
 - Elbow
 - Shin Guards
 - Shoulder
 - Neck Protectors

- Tennis
 - Rackets
 - Men's
 - Women's
 - Youth
 - Oversized
 - Balls
 - Grass
 - Hard Court
 - Heavy Duty
 - Regular Duty
 - Footwear
 - Men's
 - Women's
 - Boys
 - Girls
 - Skirts/Dresses
 - Nike
 - Adidas
 - Reebok
 - Fila

LTL/RRT: Clothing

- Mens (*Primary Level*)
 - Outerwear (*Secondary Level*)
 - Sports coats (*Tertiary Level*)
 - Lightweight jackets
 - Winter coats
 - Windbreakers
 - Pants
 - Khakis
 - Chinos
 - Cargo
 - Jeans
 - Shirts
 - Polo
 - Short Sleeve
 - Long Sleeve
 - Tanks
 - Shoes
 - Sandals
 - Outdoor/Active
 - Loafers
 - Boots
- Women
 - Shirts
 - Sleeveless
 - Short Sleeve
 - $\frac{3}{4}$ sleeve
 - Long Sleeve
 - Pants
 - Jeans
 - Khakis
 - Capri
 - Knit
 - Shoes
 - Sandals
 - Clogs
 - Heals
 - Boots
 - Accessories
 - Purses
 - Sunglasses
 - Hats
 - Watches

- Boys
 - Pants
 - Khakis
 - Jeans
 - Cargo
 - Trousers
 - Shorts
 - Knit
 - Jeans
 - Cargo
 - Other
 - Shirts
 - Polo
 - Short sleeve
 - Long Sleeve
 - Dress
 - Swimwear
 - Trunks
 - Water Shoes
 - Accessories
 - Tops
- Girls
 - Dresses
 - Sundress
 - Jumpers
 - Long
 - Formal
 - Shirts
 - Sleeveless
 - Short Sleeve
 - Long Sleeve
 - $\frac{3}{4}$ Sleeve
 - Pants
 - Jeans
 - Cargo
 - Capri
 - Flare
 - Swimwear
 - One piece
 - Two piece
 - Cover Ups
 - Accessories
- Baby
 - Premie-1year

- Sleepwear
- Tops
- Bottoms
- One pieces
- Boys (1-3 years)
 - Sleepwear
 - Tops
 - Bottoms
 - Beachwear
- Girls (1-3 years)
 - Sleepwear
 - Dresses
 - Tops
 - Bottoms

TTT: Toys

- Activities & Learning (*Primary Level*)
 - Science(*Secondary Level*)
 - Chemistry (*Tertiary Level*)
 - Nature
 - Biology
 - Oceans
 - Reading
 - Preschool
 - Kindergarten
 - Grades 1-5
 - Grades 6-8
 - Math
 - Preschool
 - K-5
 - 6-8
 - 9-12
 - Music
 - Preschool
 - K-5
 - 6-8
 - 9-12
- Bocks & Building Sets
 - LEGO
 - Sets
 - Planes
 - Cars
 - Castles
 - Blocks
 - Alphabet
 - Number
 - Wooden
 - Foam
 - Mega Blocks
 - Sets
 - Shopping Cart
 - Boats
 - Trains
 - Lincoln Blocks
 - Sets
 - Shopping Cart
 - Boats
 - Trains

- Dolls
 - Dolls
 - Porcelain
 - Barbie
 - Madeline
 - Raggedy Anne & Andy
 - Clothing
 - Dresses
 - Sweaters
 - Shoes
 - Coats
 - Accessories
 - Bibs
 - Strollers
 - Chairs
 - Miscellaneous
 - Doll Houses
 - Wooden
 - Plastic
 - Furniture
 - Sets
- Sets & Models
 - Planes
 - Boeing
 - Lockheed
 - Helicopter
 - General
 - Trains
 - Electronic
 - Wooden
 - Train sets
 - Other
 - Cars
 - Classic
 - NASCAR
 - Sports
 - Racing
 - Spaceships
 - NASA
 - Moonwalker
 - Appollo
 - Other

- Games
 - Board
 - Candy Land
 - Chutes & Ladders
 - Checkers
 - Monopoly
 - Card
 - UNO
 - Standard
 - Pokemon
 - Memory
 - Puzzles
 - Jigsaw
 - 3-D
 - Brain Teasers
 - Magnetic
 - Video
 - Action
 - Adventure
 - Hot Sellers
 - Sports

TTL/RTT: Books

- Fiction (*Primary Level*)
 - Women's Fiction (*Secondary Level*)
 - Single Women (*Tertiary Level*)
 - Mother & Children
 - Domestic Life
 - Divorce
 - General
 - Comic
 - Contemporary
 - Literary
 - Miscellaneous
 - Classics
 - American
 - Greek
 - Russian
 - Europe
 - Short Stories
 - General
 - American
 - Anthologies
 - Other
- Autobiography
 - Historical
 - General
 - British
 - US
 - Holocaust
 - Sports
 - Baseball
 - Football
 - Basketball
 - Golf
 - Leaders
 - Political
 - US Presidents
 - Royalty
 - Military
 - Children & Young Adult
 - Paperback
 - Hardcover
 - Best Sellers
 - Miscellaneous

- Mystery
 - Hardcover Best Sellers
 - Authors A-F
 - Authors G-L
 - Authors M-R
 - Authors S-Z
 - Classics
 - Agatha Christie
 - Tom Clancy
 - John Grisham
 - Stephen King
 - Paperback Best Sellers
 - Authors A-F
 - Authors G-L
 - Authors M-R
 - Authors S-Z
 - Award Winners
 - Agatha Awards
 - Edgar Awards
 - Anthony Awards
 - Jennifer Awards
- Children's
 - Classics
 - General
 - Fairy Tale
 - Fantasy
 - Dr. Seuss
 - Popular
 - Dr. Suess
 - Harry Potter
 - Disney
 - Winne-the-Pooh
 - Series
 - Horror
 - Classics
 - Humorous
 - Miscellaneous
 - Audio
 - Dr. Seuss
 - Adventure
 - Animals
 - Fantasy

- Science Fiction
 - General
 - Adventure
 - Anthologies
 - High Tech
 - Series
 - Fantasy
 - Contemporary
 - Epic
 - Magic & Wizards
 - Historical
 - Gaming
 - Dungeons & Dragons
 - Strategy
 - Vampire
 - Werewolf
 - Media
 - X-Files
 - Babylon 5
 - Batman
 - Xena

TLL: Movies

- VHS (Primary Level)
 - New Releases (Secondary Level)
 - Action/Adventure (Tertiary Level)
 - Comedy
 - Kids
 - Romance
 - Coming Soon
 - Action/Adventure
 - Comedy
 - Kids
 - Romance
 - On Sale
 - Action/Adventure
 - Sci Fi
 - Comedy
 - Kids
 - Romance
 - Top 10
 - Action
 - Comedy
 - Horror
 - Romance
- DVD's
 - New Releases
 - Action/Adventure
 - Sci Fi
 - Comedy
 - Kids
 - Coming Soon
 - Action/Adventure
 - Sci Fi
 - Kids
 - Romance
 - On Sale
 - Action/Adventure
 - Sci Fi
 - Kids
 - Romance
 - Top 10
 - Action
 - Comedy
 - Horror

- Romance
- Games
 - PS
 - Upcoming releases
 - Action
 - Adventure
 - Sports
 - PS2
 - Hot Sellers
 - Upcoming releases
 - Action
 - Sports
 - N64
 - Hot Sellers
 - Action
 - Adventure
 - Sports
 - Gameboy
 - Action
 - Adventure
 - Sports
 - Hot Sellers
- Posters
 - 1890-1919
 - Action
 - Sci Fi
 - Comedy
 - Musicals
 - 1920-1959
 - Action
 - Sci Fi
 - Comedy
 - Musicals
 - 1960-1999
 - Action
 - Sci Fi
 - Comedy
 - Musicals
 - 2000-Present
 - Action
 - Sci Fi
 - Comedy

- Musicals
- Specials
 - VHS
 - Action
 - Comedy
 - Horror
 - Romance
 - DVD
 - Action
 - Comedy
 - Horror
 - Romance
 - Games
 - Action
 - Adventure
 - Sports
 - Sci Fi
 - Posters
 - Action
 - Horror
 - Comedy
 - Sci Fi

TLT/RRR: Furniture**Bedroom (*Primary Level*)**

- Bed Frames (*Secondary Level*)
 - Metal (*Tertiary Level*)
 - Wood
 - Footboard
 - Headboard
- Mattresses
 - Twin
 - Full
 - Queen
 - King
- Dresser
 - 3-Drawer
 - 4-Drawer
 - 5-Drawer
 - 6-Drawer
- Night tables
 - Pine
 - Maple
 - Cedar
 - Oak

Living Room

- Sofas
 - Leather
 - Fabric
 - Covers
 - Sleeper
- Loveseat
 - Leather
 - Fabric
 - Covers
 - Wicker
- Tables
 - Set
 - Glass
 - Wood
 - Iron
- Rugs
 - Round
 - Oval
 - Rectangle

- Runners

Dining Room

- Tables
 - Glass
 - Wood
 - Iron
 - Marble
- Chairs
 - Tall Back
 - Iron
 - Wooden
 - Padded
- Hutches
 - Pine
 - Oak
 - Cedar
 - Maple
- Sets
 - Oak
 - Maple
 - Cedar
 - Pine

Den/Study

- Desks
 - Computer
 - Executive
 - Student
 - Other
- Chairs
 - Reclining
 - Adjustable
 - Arm Chair
 - Executive
- Lamps
 - Desk
 - Floor
 - Reading
 - Table
- Bookcases/Shelves
 - 2 Shelf
 - 3 Shelf
 - 4 Shelf
 - 5 Shelf

Patio

- Chairs
 - Arm
 - Lounge
 - Gliders
 - Padded
- Hammocks
 - Stands
 - Rope Hammock
 - Canvas Hammock
 - Miscellaneous
- Tables
 - Wooden
 - Plastic
 - Glass
 - Iron
- Umbrellas
 - 7.5'
 - 8'
 - 9'
 - 10'

Appendix F

Post Interaction Survey – Experiment 1

Final Survey

Participant # _____

1. In the box below, DRAW and LABEL the 3-level menu structure that you feel is best overall for its ease of use. Use the following labels for the first, second and third levels (1: Music, 2: Rock, 3: Bands).

2. Give a reason(s) for the menu structure you selected. What is it about this structure that you prefer?

3. Rank all eight websites that you interacted with on a scale from 1 (best) to 8 (worst) for the following dimensions.

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
TTL					
LTT					
TLT					
TTT					
TLL					
LTL					
LLL					
LLT					

4. Restate the top 3 website structures you prefer the most. For each provide a reason(s) for your preference.

#1 Site: _____
Reason:

#2 Site: _____
Reason:

#3 Site: _____
Reason:

5. List the 1 website structure that you like the least (rated #8 above). Give a reason(s) for your answer.

Site: _____

Reason:

Appendix G

Adjusted Weight Overall Score

Experiment 1

The results of the adjusted weight follow a similar trend as of the equal weight, with little variance. The top three conditions for the adjusted weight scores were LLL, LTT and LLT. See Table 35 below for a breakdown of adjusted weights and figures 66 and 67 for graphs of adjusted weights by value and rank, respectively.

Table 35

Experiment 1 Overall Adjusted Weight Scores by Value and Rank

Condition	Adjusted Weight Score	Rank
LLL	2.5642	1 (Best)
LTT	2.6666	2
LLT	3.6923	3
TTT	3.718	4
TLL	4.2564	5
LTL	5.1538	6
TLT	6.5897	7
TTL	7.2308	8 (Worst)

Figure 66. Experiment 1 overall adjusted weight scores by value.

Figure 67. Experiment 1 overall adjusted weight scores by rank.

Experiment 2

When the adjusted weight score was used, the results of the adjusted weight follow a similar trend as of the equal weight, with a little variance in order of outcome. The top four structures for the adjusted weight are LLL, RRR, TTT and RTT. Table 36 below displays the ranks and values for adjusted weight scores for each menu structure. See figure 68 for a graph of overall adjusted weight scores by rank.

Table 36

Experiment 2 Overall Adjusted Weight Scores by Value and Rank

Condition	Adjusted Weight Score	Rank
LLL	2.1539	1 (Best)
RRR	2.4616	2
TTT	3.5641	3
RTT	4.5384	4
LTT	4.5641	5
RRT	4.9487	6
TLL	5.2820	7
RTR	7.6923	8 (Worst)

Figure 68. Experiment 2 overall adjusted weight scores by rank.

Appendix H

Overall Score: Equal vs. Adjusted Weight

Experiment 1

Overall Score Comparison. A side-by-side comparison of equal-weight overall score and adjusted-weight overall score is presented in Tables 37 and 38 below. Table 37 displays each condition's overall score by value and Table 38 shows each condition's overall scores by rank. A graphical representation of the overall scores by value are displayed in Figure 69 and overall scores by rank are displayed in Figure 70.

The correlation, of adjusted overall scores and equal weight overall scores, by rank are highly positively correlated with a value of 0.965724. The correlation of both scores, by value, also resulted in a high positive correlation with a value of 0.983629. Tables 39 and 40 show the correlation results of equal versus adjusted weights by rank and value, respectively.

Table 37

Experiment 1 value comparison of adjusted weight vs. equal weight by menu structure

Condition	Equal Weight	Adjusted Weight
LLL	2.8	2.5642
LLT	3.6	3.6923
LTT	2.6	2.6666
LTL	4.6	5.1538
TTT	4.2	3.718
TTL	7.4	7.2308
TLL	4.2	4.2564
TLT	6.4	6.5897

Figure 69. Experiment 1 overall equal weight vs. adjusted weight scores by value.

Table 38

Experiment 1 rank comparison of adjusted weight vs. equal weight by menu structure

Condition	Equal Weight	Adjusted Weight
LLL	2	1
LLT	3	3
LTT	1	2
LTL	6	6
TTT	4	4
TTL	8	8
TLL	4	5
TLT	7	7

Figure 70. Experiment 1 overall equal weight vs. adjusted weight scores by rank.

Table 39

Experiment 1 Correlation of Overall Adjusted Weight vs. Equal Weight by Rank

	Equal Weight	Adjusted Weight
Adjusted Weight	0.965724	1
Equal Weight	1	

Table 40

Experiment 1 Correlation of Overall Adjusted Weight vs. Equal Weight by Value

	Equal Weight	Adjusted Weight
Adjusted Weight	0.983629	1
Equal Weight	1	

Experiment 2

Overall score comparison. A side-by-side comparison of the adjusted and equal overall scores is presented in Tables 41 and 42 below. Table 41 displays each condition's value and Table 42 shows each condition's rank. See figures 71 and 72 for a graphical representation of these side-by-side comparisons.

Table 41

Experiment 2 Comparison of Equal vs. Adjusted Overall Scores by Value

Condition	Adjusted Weight	Equal Weight
LLL	2.1539	2.2
LTT	4.5641	4.4
TTT	3.5641	4
TLL	5.2820	5.2
RRR	2.4616	2.6
RRT	4.9487	4.8
RTT	4.5384	4.4
RTR	7.6923	7.6

Table 42

Experiment 2 Comparison of Equal vs. Adjusted Overall Scores by Rank

Condition	Adjusted Weight	Equal Weight
LLL	1	1
LTT	5	4
TTT	3	3
TLL	7	7
RRR	2	2
RRT	6	6
RTT	4	5
RTR	8	8

Figure 71. Experiment 2 overall equal weight vs. adjusted weight scores by value.

Figure 72. Experiment 2 overall equal weight vs. adjusted weight scores by rank.

A correlation was performed between the overall adjusted weight scores and the overall equal weight scores. The correlation of equal weight scores and adjusted weight scores, by rank, showed a high positive correlation with a value of 0.9896. The correlation of equal weight overall score and adjusted weight overall score by value also resulted in a high positive correlation with a value of 0.9942. Tables 43 and 44 show the correlations by rank and value for overall score comparison, respectively.

Table 43

Experiment 2 Correlation of Overall Adjusted Weight vs. Equal Weight Scores by Rank

	<i>Adjusted Weight</i>	<i>Equal Weight</i>
Adjusted Weight	1	
Equal Weight	0.989569	1

Table 44

Experiment 2 Correlation of Overall Adjusted Weight vs. Equal Weight Scores by Value

	<i>Adjusted Weight</i>	<i>Equal Weight</i>
Adjusted Weight	1	
Equal Weight	0.994197	1

Appendix I

Participant Consent Form

AGREEMENT TO PARTICIPATE IN RESEARCH

Responsible Investigator(s): Jennifer R. Kingsburg, Dr. Anthony Andre

Title of Protocol: A Comparison of Three-level Menu Navigation Schemes for the Web

I understand that this experiment is part of a research project studying website usability. The results of this study will be used to provide guidelines for creating more usable web sites. I will be asked to perform a set of common web-surfing tasks over a 30-minute period with a 2-minute break at the midpoint of that period. Afterwards I will complete a 10-minute written survey. The experiment will take 1 hour to complete. I will be compensated with 2 credit hours for my participation in this study.

There are no risks associated with my participation, aside from those encountered when viewing a computer screen or operating a mouse with minimal force requirements. Any slight fatigue due to these activities will be minimized by the break times provided during participation. Although there are no direct benefits to participants, I may leave at the conclusion of this experiment with the knowledge that my involvement benefited future advances in website menu design.

No service of any kind, to which I am entitled, will be lost or jeopardized if I choose to "not participate" in this study. I am free to withdraw at any time during the course of the study, without prejudice to my relationship with either San Jose State University or Interface Analysis Associates.

By signing this form I give consent to participate in this study. I acknowledge that this session will be videotaped for the purposes of data analysis. By signing this form, I agree to have my participation recorded on videotape, and to have the videotape used for further analysis. In the event that the visual images are shared with the public, my identity will be protected (any personally identifying parts of the image will be purposely obscured). The results of the study may be published, but no information that could identify me will be included.

I understand that questions about the research may be addressed to investigator Jennifer Kingsburg at (408) 972-8796. Complaints about the research may be presented to Louis E. Freund, Ph.D., Chair, Department of Industrial and Systems Engineering, at (408) 924-3890. Questions or complaints about research or subjects' rights may be presented to Nabil Ibrahim, Ph.D., Associate Vice President for Graduate Studies and Research, at (408) 924-2480.

Finally, it is clear to me that:

1. I give my consent to participate knowing that my actions and image will be recorded on videotape during the experiment.
2. My participation is entirely voluntary (given freely).
3. I may refuse to participate in this study, or in any part of this study, and I am free to withdraw from the study at any time.

Please sign and date both copies of this form, indicating your agreement to participate. At that time, you will receive a copy of this form, signed and dated by the investigator.

Participant's signature

Date

Investigator's signature

Date

APPENDIX J

Experimenter Instructions

INTRODUCTION

1. Greet participant
2. Participant Instructions

“For the purposes of today let’s imagine you’re at home and want to purchase a couple of items online. You will be asked to shop for different items at different stores. Use the lists provided in front of you to complete each set of tasks for each store. For each task printed in front of you please read the task to yourself first. After you have read to yourself, read it out loud again. Once you have read the task out loud you can start the task by selecting the “Start Task” button. In order to purchase an item you must click on the picture, where you will see a confirmation page. After you have landed on the confirmation page for the task you must select the “Task Track” button to mark the completion of the task. Then please take your hand off the mouse and read the next task. The same procedure will be used for each set of tasks. Once you complete all tasks on the page for a given store I will then come in and set you up for the next set of tasks. Remember, try to complete each task as accurate and fast as you can.”

PART I

1. Start recording and mark tape for the first set of 8 websites.
2. Record any facial expressions or comments made during interaction with each website.
3. Record any cursor movement observations.
4. After task 6 for condition X, go into lab room and set up participant for next condition.
 - a. Clear the History within the web browser under the "Internet Tools" option.
 - b. Do Ctr +R to refresh the screen.
 - c. Open the home page on the next website to be used.
5. At end of last website (#8) pause tape.

BREAK

1. After the 8th website give participant a two minute break.
2. Clear the History within the web browser under the "Internet Tools" option.
3. Do Ctr +R to refresh the screen.
4. Open the home page on the next website to be used.

PART II

1. Remind participant of goal (accurate and fast).
2. Start recording and mark tape for second set of websites.
3. Record any facial expressions or comments made during interaction with each website.
4. Record any cursor movement observations.
5. At end of last website (#16) pause tape.

FREE-FORM WEBSITE NAVIGATION

1. Have participant browse on own for 1 minute per condition for all eight conditions.
2. Record free-form navigation.
3. At the end of eight minutes stop tape.

DRAWING TASK

1. Have participant fill out page 1 of final survey.

FINAL SURVEY

1. Participant fills out final survey.
2. When completed double check that all questions were completed and are consistent (e.g., overall preference (#1) is the same on questions 2 and 3.

DEBRIEF AND PAYMENT

1. Answer any questions participant has regarding the study.
2. Sign participant credit sheet and thank participant.

Appendix K
Example Task Set

Clothing

1. Purchase a light blue short sleeve girls shirt.
2. Purchase the baby sports bib from the Accessories section.
3. Purchase a winter leather men's coat.
4. Purchase a pair of hiking cargo men's pants.
5. Purchase a pair of pleated front khaki men's pants.
6. Purchase a pink 2-piece bathing suit for a girl.

Sports

1. Purchase a black Sun brand hockey puck.
2. Purchase a black Nike tennis skirt.
3. Purchase a junior size Champion brand basketball.
4. Purchase a blue USA customized basketball jersey.
5. Purchase a NY Knicks home NBA basketball jersey.
6. Purchase a Nike shin guard hockey pad.

Furniture

1. Purchase a red cloth adjustable chair for your den.
2. Purchase the Mt. View 7.5' patio umbrella.
3. Purchase a marble footboard bed frame.
4. Purchase a standard queen mattress for your bed.
5. Purchase a quilted twin mattress.
6. Purchase an oak 3-shelf bookcase for your den.

Toys

1. Purchase the 5 piece wooden model train set.
2. Purchase the action video game *Goofy's Fun House*.
3. Purchase the Smithsonian biology activities and learning kit.
4. Purchase a third grade reading activities toy.
5. Purchase a preschool reading tower activities toy.
6. Purchase the moonwalker XXV spaceship model.

Electronics

1. Purchase a 600 MHz AT&T cordless phone.
2. Purchase the Sony DIG radio.
3. Purchase the RCA R2635 DVD.
4. Purchase a 27" Mitsubishi TV.
5. Purchase a 25" RCA TV.
6. Purchase the GE G2535 answering machine.

Books

1. Purchase the popular Harry Potter book, *Scorcerer's Stone*, from the children's section.
2. Purchase the media book, *X-Files Part 2*, from the science fiction section.
3. Purchase the domestic life, women's fictional book, *Next of Kin*, by Joanna Trollope.
4. Purchase the general literary fictional book, *Fight Club*.
5. Purchase the general comic fictional book, *4 Blondes*.
6. Purchase the audio adventure children's book, *Holes*.

Movies

1. Purchase the 1950's sci fi poster, *The Man from Planet X*.
2. Purchase the action poster, *Gladiator*, from the Specials section.
3. Purchase the newly released kids movie, *Rugrats the Movie*, on VHS.
4. Purchase the kids movie, *Monkey Bone*, that is coming soon on VHS.
5. Purchase the action/adventure movie, *Memento*, that is also coming soon on VHS.
6. Purchase the year 2000 Sci Fi poster, *Star Wars*.

Computers

1. Purchase the Halfway brand Ergonomic keyboard from the Peripherals section.
2. Purchase the drawing software program Pro Draw3.
3. Purchase the B1200 Compaq desktop PC.
4. Purchase the Sony 1600 notebook PC.
5. Purchase the Apple 920Xi notebook PC.
6. Purchase the Hitachi DVD drive from the Peripherals section.

Computers

1. Purchase a Canon 6300 scanner.
2. Purchase a Canon L550X inkjet printer.
3. Purchase a Lexmark L2300 inkjet printer.
4. Purchase the 626 model 19" IBM monitor.
5. Purchase the 666 model 15" NEC monitor.
6. Purchase the 197 model 19" NEC monitor.

Movies

1. Purchase the DVD, *The Wedding Planner*, from the On sale romance section.
2. Purchase the DVD, *Gladiator*, from the new released action section.
3. Purchase the DVD, *Digimon*, from the new released kids section.
4. Purchase the PS adventure video game, *Rugrats in Paris*.
5. Purchase the hot selling PS2 video game *Extermination*.
6. Purchase the action PS2 video game *Dark Cloud*.

Books

1. Purchase the military leaders autobiography, *Lee*.
2. Purchase the book, *West with the Night*, from the historical general autobiography section.
3. Purchase the historical holocaust autobiography, *All But My Life*.
4. Purchase one of Greg Rucka's hardcover best sellers mystery books.
5. Purchase the Agatha Christie classic mystery, *A Pocket Full of Rye*.
6. Purchase the John Grisham classic mystery, *The Brethren*.

Electronics

1. Purchase an 18 exposure single use wedding camera.
2. Purchase the Olympus D260 digital camera.
3. Purchase the Fuji F230 digital camera.
4. Purchase the Handspring H1600 PocketPC PDA.
5. Purchase the Franklin F453 ebook PDA.
6. Purchase the Blackberry B333 ebook PDA.

Toys

1. Purchase the mega, Set 2, train set blocks.
2. Purchase the LEGO space station block set.
3. Purchase the LEGO King Arthur's castle blocks.
4. Purchase the Nun doll from the Madeline doll section.
5. Purchase the pink floral doll dress.
6. Purchase the set of 6 doll shoes.

Furniture

1. Purchase a Broyhill iron living room table.
2. Purchase an Edgewood leather sofa.
3. Purchase a Birmingham sleeper sofa.
4. Purchase the tall iron dining table.
5. Purchase the chenille tall back dining chair.
6. Purchase a cedar wood dining chair.

Sports

1. Purchase a gray practice football jersey.
2. Purchase an official Spalding football.
3. Purchase a yellow foam football.
4. Purchase an LA fitted baseball hat.
5. Purchase a pair of dark gray men's baseball pants.
6. Purchase a pair of blue stripe boys baseball pants.

Clothing

1. Purchase a pair of brown leather women's boots.
2. Purchase a stripe sleeveless women's shirt.
3. Purchase a rose colored long sleeve women's shirt.
4. Purchase a pair of gray cargo boys pants.
5. Purchase a pair of beige knit boys shorts.
6. Purchase a pair of zip cargo boys shorts.

APPENDIX L

Survey Summary – Experiment 1

1. In the box below, DRAW and LABEL the 3-level menu structure that you feel is best overall for its ease of use. Use the following labels for the first, second and third levels (1: Music, 2: Rock, 3: Bands).

Site	Frequency
LTL	(x0)
LTT	(x2)
TLT	(x0)
TTT	(x4)
LLT	(x2)
TTL	(x0)
TLL	(x1)
LLL	(x7)

2. Give a reason(s) for the menu structure you selected. What is it about this structure that you prefer?

Website: LTT

- It's easiest to navigate from one main section then to move to the right and have all sub-sections and sub-sections on the right.
- The first level I placed to the left so the user could select which area he or she will be wanting to shop for. The second stage at the top would display the different areas in the selected topic. The first stage would represent a detailed description of the category in that area of the topic.

Website: LLL

- I chose the left side because it's much easier to read and you can just go down the list. There's no confusion.
- For me and I guess most people (English speaking and reading) we read from left to right, up to down. And this way it's organized and it gives me room for info on this side.
- It is more understandable, and it's easier to see. When everything is one side (left for example) it's easier to follow then when it is on the top.
- I used this system because it's easy to use. Not taking up a lot of space. It's laid out and simple. Not messy.

- Since rock and band is under the music category, it would be easier for me to identify it on the left hand side of the screen.
- It's easy to retrace your steps, when the selection is on the side and the viewing screen is to the right. You can easily go back to a different category and check out another one.
- I prefer sublevels under the main level for ease of navigation and when selecting it will show in the content box.

Website: TTT

- Expected progression (position wise) of the menu structure. Intuitive.
- You can see everything you have selected very quickly and easily. It's all in one line coming down or all in one general area on the screen.
- I prefer the above structure. I think this will be easier to search for the levels and I would seek since it seems more in order and less likely be confusing.
- Flow of classification top to bottom subdivisions under the main heading.

Website: TLL

- I usually use and see this structure online.

Website: LLT

- A menu needs to be easy and not time consuming. When a person wants to buy something it is usually a spur of the moment and if the product is difficult to find the person may leave the site. Therefore, it should be as easy as 2-3 clicks to find.
- I usually look to the left of the screen before I look to the top., Generally the existing websites that I feel most comfortable using have this structure. Also, this is a well organized site. The front page would have the menu n the left while the large graphic or their name would be in the center.

3. TOTAL POINTS

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference	TOTAL	Average
TTL	83	82	83	85	84	417	26.06
LTT	61	55	59	56	56	287	17.94
TLT	108	113	111	104	109	545	34.06
TTT	44	42	41	44	44	215	13.44
TLL	62	61	69	68	67	327	20.44
LTL	116	116	116	112	113	573	35.81
LLL	33	39	36	39	38	185	11.56
LLT	69	68	61	68	65	331	20.69

Frequency for MOST preferred (#1)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
TTL					1
LTT	2	2	2	1	2
TLT					
TTT	4	4	3	4	2
TLL	2	2	2	2	2
LTL					
LLL	6	6	6	6	6
LLT	2	2	2	3	3

Frequency for SECOND most preferred (#2)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
TTL				1	
LTT		2	2	2	2
TLT					
TTT	7	7	8	7	9
TLL	1	2			
LTL					
LLL	8	5	5	5	4
LLT			1	1	1

Frequency for THIRD most preferred (#3)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
TTL	2	2	3	1	1
LTT	3	4	2	5	4
TLT					
TTT		1	1	1	2
TLL	4	3	3	3	3
LTL	1				
LLL	1	2	1	2	3
LLT	5	4	6	4	3

Frequency for FOURTH most preferred (#4)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
TTL	3	1	1	2	2
LTT	6	5	6	6	4
TLT				2	1
TTT	1	1	2	1	1
TLL	3	3	3	3	3
LTL		1		1	1
LLL		1	2		1
LLT	3	4	2	1	3

Frequency of FIFTH most preferred (#5)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
TTL	3	1	1	2	2
LTT	6	4	6	6	4
TLT				2	1
TTT	1	1	2	1	1
TLL	3	3	3	3	3
LTL		1		1	1
LLL		1	2		1
LLT	3	4	2	1	3

Frequency of SIXTH most preferred (#6)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
TTL	3	2	4	5	7
LTT	1	2			
TLT	3	2	1	1	
TTT	1	1		1	1
TLL	3	3	6	2	3
LTL	1	1	2	1	2
LLL				1	
LLT	4	5	3	5	3

Frequency of SEVENTH most preferred (#7)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
TTL	2	1	1	2	1
LTT				1	1
TLT	8	8	12	8	9
TTT					
TLL				1	
LTL	5	6	2	4	4
LLL					
LLT	1	1	1		1

Frequency for LEAST preferred (#8)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
TTL	1	1	1	1	1
LTT			1		
TLT	3	5	2	3	4
TTT	1	1	1	1	1
TLL					
LTL	9	8	10	8	8
LLL	1	1	1	1	1
LLT	1			2	1

4. Restate the top 3 website structures you prefer the most. For each provide a reason(s) for your preference.

#1 Site: LTT

- Seems like a fluid motion. Like you are going clockwise.
- Went from one side of the screen to the other.

#1 Site: LLL

- Not confusing. To the point.
- Easiest to follow.
- It's easier to see and follow.
- It's good to group items together. The left side is where I look at first.
- Progression was easiest to follow.
- Real easy to see, easy to go back, easy to navigate.

#1 Site: TTT

- Consistent, intuitive.
- Since everything here is in order from top to bottom. It seems easier because my eyes don't have to wander around.

#1 Site: TLL

- I like this site because it's very easy to navigate. You look from the top to the side. The eye focusing on one thing too long can be tiring.

#1 Site: TTL

- It shows the most specific category the largest. And the other two in order from most general to least.

#1 Site: LLT

- I like this one because it is easy to navigate. The final outcome is solo, which makes it easy to examine.
- I look left most often than to the top.
- Simple and easy to navigate quickly.

#1 Site: TLL

- After you click on the subject, the category on the left will show out with number 3. More convenient and easy to complete task.

.....

#2 Site: TTT

- Not confusing. To the point.
- Easy to follow, stays in the same place.
- It's easier when the structure doesn't change. Either TTT or LLL, but in this case LLL was easier for me.
- It's best to group categories (similar items) together. The top is where I look first.
- Easy progression. Compresses the screen.
- Although this is opposite of my least favorite it is much easier to read it in this way.
- They are all in the same place and I don't have to really look all over the screen to find the next menu.
- Almost as good as LLL, but a little awkward because it's on top. But overall good because the steps stay together. Easy to go back, navigate and not get lost.
- Went form top to bottom, easy to follow.

#2 Site: LLT

- Seems like second closest to traveling clockwise.

#2 Site: LLL

- Consistent
- There is no confusion. Everything on the left.
- Same as above...consistent and eyes don't have to wander. More in order for searching the sites.

#2 Site: LLL

- Everything on the side is clean and neat. You can put more on the middle and right side. More than the ones you have a heading on.

#2 Site: LTT

- You can see the largest category down the side and the other two together. I like it in order and only one category on the side.
- Easy to see and understand.

.....

#3 Site: TLL

- The first menu on the top but the rest at left is also easy.
- I like the category on top while the similar items at left.
- Not too confusing. You can at least attempt to go in order.

#3 Site: LTT

- Same as LLT it jumps but then stays the same.
- Less consistent and intuitive but ok after the first level is passed.
- All the main subject on the left. Then it is categories only on top. Less confusion too.
- Harder to change from left to top.

#3 Site: LLL

- You need only visit two sections of the screen. Left and the select of the item.
- They are all in the same place and I don't have to really look all over the screen to find the next menu.
- Keeps all levels together and easy to use.
- Stayed at one side of the screen.

#3 Site: TTT

- Pretty straight forward. It descends in rows. Very simple. No clutters on the sides.
- Everything comes from the top in order. It's easy to see everything and keep track of order.

#3 Site: LLT

- Prefer as well since my eye movements are going in direction from left to right.
- This one is also my favorite because the first two labels stay on the left and the step chosen is on top. Easy to navigate and go back and select a different category

#3 Site: TTL

- Once again it's following steps and the final product is alone, not mixed up with other words to be confused by.
5. List the 1 website structure that you like the least (rated #8 above). Give a reason(s) for your answer.

Site: LLT

- The category should be first so people would know where to go.

Site: LTL

- You have to jump back and forth.
- Too jumpy- hard to follow.
- Takes too long. From the left to top to back to the left to the right to select items.
- It's confusing to find the menu. I didn't know where to look for it.
- Too much confusion with the eyes and mind. Going back and forth for links would take too long and is a big distraction.
- Confusion. Click #1 for subject. Then go top and search for a category and then move left again. Error will occur most at this time because people will click 1, then 3 immediately.
- It's out of order to me the least specific and most specific are together and the middle (which isn't what you're really looking at) is the dominant one.
- Takes time for searching since the directions are not coordinate to at least one way.

Site: TTL

- I spent most of my time jumping between levels 2 and 3. It was uncomfortable because links position wasn't where I expected it to be.

Site: TLT

- The alternative between top and left was harder to follow.
- I don't like things scattered across the screen. The less I have to move my eye while surfing, the better.
- Very confusing. The labels jump around from top to left and again to top. Would be very irritating to browse this web site.
- Had to search all over the screen for my options.

Site: LLL

- There is too much going on in one area. IT needs to be spread out. So all the options can be looked at.

Site: TTT

- I never liked structures filling in from the top of the screen.

6. Which menu structure have you experienced the most?

Site	Frequency
LLL	(x6)
LTT	(x2)
LLT	(x4)
TTL	(x1)
TLL	(x3)

Appendix M

Menu Structure Interaction Order – Experiment 2

Menu Structure Order																	
Participant Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	RRT	LTT	RRR	TTT	RTR	RTT	TLL	LLL	LLL	TLL	RTT	RTR	TTT	RRR	LTT	RRT
	2	LTT	RRR	TTT	RTR	RTT	TLL	LLL	RRT	RRT	LLL	TLL	RTT	RTR	TTT	RRR	LTT
	3	RRR	TTT	RTR	RTT	TLL	LLL	RRT	LTT	LTT	RRT	LLL	TLL	RTT	RTR	TTT	RRR
	4	TTT	RTR	RTT	TLL	LLL	RRT	LTT	RRR	RRR	LTT	RRT	LLL	TLL	RTT	RTR	TTT
	5	RTR	RTT	TLL	LLL	RRT	LTT	RRR	TTT	TTT	RRR	LTT	RRT	LLL	TLL	RTT	RTR
	6	RTT	TLL	LLL	RRT	LTT	RRR	TTT	RTR	RTR	TTT	RRR	LTT	RRT	LLL	TLL	RTT
	7	TLL	LLL	RRT	LTT	RRR	TTT	RTR	RTT	RTT	RTR	TTT	RRR	LTT	RRT	LLL	TLL
	8	LLL	RRT	LTT	RRR	TTT	RTR	RTT	TLL	TLL	RTT	RTR	TTT	RRR	LTT	RRT	LLL
	9	RRT	LTT	RRR	TTT	RTR	RTT	TLL	LLL	LLL	TLL	RTT	RTR	TTT	RRR	LTT	RRT
	10	LTT	RRR	TTT	RTR	RTT	TLL	LLL	RRT	RRT	LLL	TLL	RTT	RTR	TTT	RRR	LTT
	11	RRR	TTT	RTR	RTT	TLL	LLL	RRT	LTT	LTT	RRT	LLL	TLL	RTT	RTR	TTT	RRR
	12	TTT	RTR	RTT	TLL	LLL	RRT	LTT	RRR	RRR	LTT	RRT	LLL	TLL	RTT	RTR	TTT
	13	RTR	RTT	TLL	LLL	RRT	LTT	RRR	TTT	TTT	RRR	LTT	RRT	LLL	TLL	RTT	RTR
	14	RTT	TLL	LLL	RRT	LTT	RRR	TTT	RTR	RTR	TTT	RRR	LTT	RRT	LLL	TLL	RTT
	15	TLL	LLL	RRT	LTT	RRR	TTT	RTR	RTT	RTT	RTR	TTT	RRR	LTT	RRT	LLL	TLL
	16	LLL	RRT	LTT	RRR	TTT	RTR	RTT	TLL	TLL	RTT	RTR	TTT	RRR	LTT	RRT	LLL

LLL: Clothing

LTT: Sports

TTT: Toys

TLL: Movies

RRR: Furniture

RRT: Clothing

RTT: Books

RTR: Electronics

Appendix N

Post Interaction Survey – Experiment 2

Final Survey

Participant # _____

1. In the box below, DRAW and LABEL the 3-level menu structure that you feel is best overall for its ease of use. Use the following labels for the first, second and third levels (1: Music, 2: Rock, 3: Bands).

2. Give a reason(s) for the menu structure you selected. What is it about this structure that you prefer?

3. Rank all eight websites that you interacted with on a scale from 1 (best) to 8 (worst) for the following dimensions.

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
RRL					
LTT					
RTR					
TTT					
TLL					
RRR					
LLL					
RTT					

4. Restate the top 3 website structures you prefer the most. For each provide a reason(s) for your preference.

#1 Site: _____
Reason: _____

#2 Site: _____
Reason: _____

#3 Site: _____
Reason: _____

5. List the 1 website structure that you like the least (rated #8 above). Give a reason(s) for your answer.

Site: _____

Reason: _____

Appendix O

Survey Summary – Experiment 2

1. In the box below, DRAW and LABEL the 3-level menu structure that you feel is best overall for its ease of use. Use the following labels for the first, second and third levels (1: Music, 2: Rock, 3: Bands).

Site	Frequency
RRT	(x3)
LTT	(x1)
RTR	(x0)
TTT	(x4)
TLL	(x0)
RRR	(x3)
LLL	(x3)
RTT	(x1)
TLR	(11)

2. Give a reason(s) for the menu structure you selected. What is it about this structure that you prefer?

Website: LTT

- Because it seems the most clear after I click on something on the left or right I automatically look for results at the top or center of the page.
- The reason for the menu structure is that its more organized this way and easier to follow. It wont' confuse people like others do.

Website: LLL

- Menu on the left hand side of the screen is the easiest to see. I especially like when you open a link and several new links are listed right underneath this.
- To me, the first thing that I look at is left column of this page, so I would want the links to be on the left side. It seems to be easier to have the links on the left side and having the information/material show up on the right side.
- Easier to distinguish categories and subcategories. Categories can be either on the right or left side of the screen. It doesn't matter.
- Each level is right under the other on the left side because you read from left to right. It looks more organized this way.

- The general way of reading or following directions when giving them is from left to right. The eye naturally tends to look over things in this manner automatically.

Website: TTT

- I think this structure is the easiest for me to understand.
- I picked this way because it is simple and easy to follow. Menu bars on the side are OK, but sometimes don't catch my eye as much as ones on the top. It is very confusing to have music on the top, rock on the side and then bands on the top again (user is referring to bouncing back and forth, such as TLT, LTL or RTR).
- It is easy to see and read and it moves from general to specific. It is clear and the view does not have to travel back and forth for different menus.
- My attention always goes to the top of the page. Also, I like to see what the item I am looking at along with the pictures and it being on the top seems the easiest place to see it.

Website: RTT

- It's easy to use. It makes you more perceptive to what is around. I like to look around when I'm navigating.
- I liked this structure the most because basically since I'm right handed it was easier or natural for me to just look towards the right side and choose. If I would choose the next ideal spot after would be on the top and have the picture right under the choices.

Website: RRT

- Minimized the number of times your eyes have to jump across the screen to find what you're looking for. It's organized, neat, and it looks good that way.
- I like having the first tow choices on the right hand column because I'm right handed and my mouse cursor tends to be on this side of the screen. Now, I like the 3rd choice to be on the top because it would get too cluttered on the right if there are too many choices.
- I'm right handed, so it is easier to start on the right. It may sound lazy, but I don't have to move the mouse as much as if I would have started on the left.

Website: RRR

- All of the submenus are directly under the category instead of on a separate frame. So it's pretty quick to see.
- The general topic should be at the top. The next one is getting more specific and should be a subcategory.

- I usually like things on the left since I'm left-handed, but having the menus on the right seemed to catch my eye quicker. I think the reason for this is because I'm using the mouse with my right hand, so moving the mouse all the way to the left of the screen would take more time and movement for me. Or seeing the menu from the top across the screen seemed to take too long to find what I was looking for.
- I like to have the info on my right hand side, which is why I chose this design. I feel that it is easier to have the information in one place rather than spread out on the page.

Website: TLL

- I like the way everything is spaced out instead of cluttered together all on one side or all on the top or bottom. I like using the whole screen.

3. TOTAL POINTS

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference	TOTAL	Average
RRT	73	73	77	73	74	370	
LTT	72	78	79	82	72	383	
RTR	108	117	108	110	117	560	
TTT	61	63	61	64	66	315	
TLL	83	77	81	80	75	396	
RRR	55	43	50	51	51	250	
LLL	52	57	51	48	52	260	
RTT	72	68	69	68	69	346	

Frequency for MOST preferred (#1)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
RRT	2	2	2	2	3
LTT	1	1	1	1	1
RTR					
TTT	2	2	4	4	2
TLL	2	1			1
RRR	4	4	4	4	4
LLL	4	4	3	3	4
RTT	1	2	2	2	1

Frequency for SECOND most preferred (#2)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
RRT		1	1	1	1
LTT	2				
RTR	1		1	1	
TTT	3	2	2		1
TLL	2	1	2	2	3
RRR	4	8	4	5	5
LLL	3	3	5	6	4
RTT	1	1	1	1	2

Frequency for THIRD most preferred (#3)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
RRT	4	1	1	1	1
LTT	2	2	2	2	2
RTR	1		1		
TTT	4	5	3	4	5
TLL		2	1	3	2
RRR	1	1	2	3	3
LLL	2	3	4	2	2
RTT	2	2	2	1	1

Frequency for FOURTH most preferred (#4)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
RRT	1	5	3	3	1
LTT	2	1	3	2	7
RTR					
TTT	3	3	3	3	3
TLL		4	2	2	
RRR	3				
LLL	3	1	1	3	1
RTT	4	2	4	3	4

Frequency of FIFTH most preferred (#5)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
RRT	3		2	2	3
LTT	5	8	4	5	2
RTR	2	2	1	3	2
TTT			1	1	1
TLL	1		4		1
RRR	1	1			
LLL	1	1			3
RTT	3	4	4	5	4

Frequency of SIXTH most preferred (#6)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
RRT	2	3	2	5	2
LTT	1	2	4	1	2
RTR		1	2	1	1
TTT	1		1		1
TLL	6	4	3	4	6
RRR				1	1
LLL	2	1			
RTT	4	5	4	4	3

Frequency of SEVENTH most preferred (#7)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
RRT	4	4	4	2	5
LTT	2	1		4	1
RTR	3	3	2	1	3
TTT	1	2	2	1	
TLL	4	4	4	5	3
RRR	1	1	2	2	2
LLL	1	1	2	1	1
RTT					1

Frequency for LEAST preferred (#8)

	Fastest to complete tasks	Easiest to navigate between links	Easiest to navigate accurately with fewest errors	Most Intuitive	Overall Preference
RRT			1		
LTT	1	1	2	1	1
RTR	8	10	9	10	11
TTT	2	2	1	3	2
TLL	1				
RRR	2	1	2	1	1
LLL		2	1	1	1
RTT	1				

4. Restate the top 3 website structures you prefer the most. For each provide a reason(s) for your preference.

#1 Site: LTT

- Because it seems the most clear after I click on something on the left or right. I automatically look for results at the top or center of the page.
- I like this because I'm used to starting on the left and from there I start to go to the right side (top) and going under that menu is easier to follow.

#1 Site: LLL

- Because all the links are together and easy to see.
- Used to reading from left to right.
- Everything is on one side, from left to right.
- All in one area. Tendency to focus on the left being left handed.
- The items would be off to one side and in order so there is no confusion to what I am viewing.
- It is easiest for me to scroll from left to right when looking or following directions.

#1 Site: TTT

- I like this one the best because they are all in the same area and they are all on top. When the menus are on top it is easier for me to understand.
- You don't have to go searching around the page looking for the next link. It's right there. Also, seems to stand out more when page initially loads.

#1 Site: RTT

- It's the one that I drew and it seems like the one I would like to see on future sites.

- The main choice is separated and the other choice would go to the top of the screen and give you the specifics right under.

#1 Site: RRT

- It doesn't make your eyes jump across the screen a lot when looking at the different menus, but it doesn't jumble everything into one area.
- I'm right handed and prefer to keep my cursor on that side of the screen.
- It's the least movement and least clutter.

#1 Site: RRR

- All of the categories and menus are places in one simple area.
- I like everything on the right hand side. The order flows.
- Easier for my eye to catch. Easier to find things (all menus in the same area).
- Easily shows all categories and subcategories. 1 and 2 are interchangeable, no preference to the right or left side.
- I like to have all the information in one area all the time and having it at my right works best for me.

#1 Site: TLL

- Because I like the first menu on top and then the next tow being right by each other.

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#2 Site: TTT

- Easy to see without having to adjust the screen.
- Seems easier than RRR.
- Looking down in order.

#2 Site: RRR

- While it jumbles things into one area, the right side is a better place to do it. I tend to look to the right more, so it seemed easier than LLL.
- This one is good because I am right handed so it's easier for me to see them. They are all in the same area.
- It is cluttered but everything is easy to find.
- Because it's all on one side and it just keeps you going without confusion.
- Again, all in one place. No unnecessary arm movements.
- It would be easy, but it would get a little cluttered.

#2 Site: RTT

- Because it seems the most clear after I click on something on the left or right I automatically look for results at the top or center of the page.
- I am used to seeing a lot of choices on the top of the screen.

#2 Site: RRT

- It's the next best one to the RTT.
- Because it's similar to my first choice (RTT).

#2 Site: LLL

- All of the categories and menus are places in one simple area.
- The left side is easy to navigate.
- Easier to find things (all menus in same area).
- I am used to it because it is common on the internet and I like TTT all the links are in the same place.
- Easily shows all categories and subcategories. 1 and 2 are interchangeable, no preference to the right or left side.
- Having all the information on the left is my second choice.

#2 Site: TLL

- It is nice to have the main item on the top and the smaller items off to the one side so you know what the main item you are viewing.
- Again, I like everything to the left as much as possible.

.....

#3 Site: RRR

- All of the options were together still but hard to look back and forth from menu to product.
- It's grouped together making it easier to find links.
- All links in the same place.
- I'm right handed and prefer to keep my cursor on that side of the screen.
- Also, because it's similar to my top two choices (RTT and RRT).

#3 Site: LLL

- They are all in the same area.
- Everything is easy to find. Just have to look on one side of the screen.
- This is the same reason as "RRR" since its all on one side you don't have to go back and forth like "RTR".

#3 Site: TLL

- The top is an unusual place to start, but it is sort of like the mirror image of the RRT, so it's not bad.
- The TLL works alright too. It's easy.
- Starts at top and goes to left. I read from left to right.

#3 Site: TTT

- With the top option I feel as if everything I need to see is in front of me making a list instead of jumping from one side of the screen to another.
- The top also works when everything is on top.
- Easier to find things. Eyes don't jump all over the screen.
- So used to seeing structure on the web on either right or left side. But still shows categories in an organized manner.
- I like the information together and having it on the top.
- All in one place, can see all options.

#3 Site: RRT

- Most of the categories and menus are on the right, then you just look up top for the product, then the main frame to view the product.

#3 Site: LTT

- Similar to the TLL. It still separates the main item to the lesser items just in the opposite structure.
- It's natural for me to look over things in this manner.

#3 Site: RTT

- I like starting on the right, then the top is a lot better than the left.

5. List the 1 website structure that you like the least (rated #8 above). Give a reason(s) for your answer.

Site: RTR

- Unorganized all together. Hard to read.
- Too confusing. Everything is scattered. You have to look to the right, then top, then the right.
- That's the worst one for me. I don't see why I should go back and forth to the right where I started. It just does not feel right to go from right to the top and back to the right again.
- It gets a little confusing. You have to jump around too much.
- I don't like the organization structure. It does not flow at all.
- This structure is too confusing. You choose a link but you have to go back and forth.
- Jumping from one area of the screen to another and back to same area lost me.
- Makes me search around the page for the next link, never know where it will be.
- Confusing as to when to go back to the original categories. Unorganized.
- Because you are forced to look between the right and top of the screen.

- Because first you're on the right side then you have to go to the top and go back right. Too confusing.
- Got confused where all options were. Had to keep looking around.
- It seems complicated and the items seemed to be mixed, making it difficult to use.
- I would be clicking at the top and then I wouldn't look back to the right, so it got confusing.
- Because you have to look 3 different ways. It's kind of confusing at times.

Site: TTT

- There are too many frames. It looks odd and ugly. It feels somewhat disorganized.
- Being at the top. Everything is even more cluttered. I hardly look at the top of the computer when I'm on it.

Site: LLL

- The organization is a mess. You have to scan the menu options more to make sure you are at the right links.

Site: RRR

- I don't like everything on the right. I focus more on the left side.
- I am performing backwards than the normal way I usually address things.

Site: LTT

- I don't like dragging my cursor to the left of the screen.

6. Which menu structure have you experienced the most?

Site	Frequency
RRR	(x3)
RRT	(x2)
TTT	(x3)
TLL	(x3)
LLL	(x8)
LTT	(x1)