Location Breadcrumbs for Navigation: An Exploratory Study

by

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Abstract

Location breadcrumbs are a navigation tool used in World Wide Web (WWW) browsers, to show the position of the current webpage in the website structure. We developed menu breadcrumb, a novel extension to the existing location breadcrumb method: in addition to providing the usual sequence of links, menu breadcrumbs include pull-down menus showing the links that are available at each webpage in the sequence.

The current study is to determine whether further development of menu breadcrumbs is warranted, and what avenues for future research on them are interesting.

Forty subjects participated in our information searching experiment by navigating with two different breadcrumb techniques using two different websites (in two sessions). We measured subjects' speed, frequency of use, 'lostness', and satisfaction. Except for a significant site effect on the lostness measure in the first session, in our experiment, navigating with menu breadcrumbs was no worse than regular location breadcrumbs.

Acknowledgement

I would like to thank everyone who participated in this experiment. I would like to thank Dr. Jamie Blustien, Mr. Andy Edmonds, Dr. Jack Duffy, and Dr. Kori Inkpen who provided immeasurable assistance to the research. I would also like to thank my wife and my parent for their continuous support of my education.

Chapter 1 Introduction

Internet users can easily get lost and experience difficulty finding information online (Nielsen, 1998). Therefore, many navigation tools are developed to provide quick and easy access to information. One of them is breadcrumbs. In theory, breadcrumbs are ideal for navigating large sites as the technique provides information to users about the site structure, and gives a way for them to select links from the breadcrumbs to go up in the site hierarchy. Breadcrumbs come in three forms, location breadcrumbs, path breadcrumbs, and attribute breadcrumbs. The current study investigates the location breadcrumbs in the context of people searching for information on the WWW. Unlike menus, breadcrumbs show one path through the site hierarchy. We developed a novel extension of existing breadcrumbs — menu breadcrumbs. In addition to providing a list of links about the position of the current webpage within the site hierarchy, the menu breadcrumbs provide pop-up menus of the links available from the webpages represented by the breadcrumbs. We expect that the menu breadcrumbs will give users more precise understanding of the site structure and encourage them to use the technique more frequently. In this study, we compared menu breadcrumbs to non-menu breadcrumbs to investigate whether menu breadcrumbs were more beneficial than non-menu breadcrumbs in terms of speed, frequency of using breadcrumbs, P.A. Smith's lostness (Smith, 1986), and satisfaction.

The structure of the thesis is as follows. Chapter 2 addresses the issue of user navigational behavior, the general concept of breadcrumbs, and recent studies about its

utility. We describe our development of menu breadcrumbs in Chapter 3. In Chapter 4, the experimental procedure and environment is illustrated. Chapter 5 formulates the hypotheses. The experiment results are presented and discussed in Chapters 6 and 7. Chapter 8 includes suggested future work and Chapter 9 the conclusion.

Chapter 2 Literature Review

2.1 Background

Site navigation is fundamental for a usable website. According to McGovern (2001), the purpose of navigation is to:

- "Present readers with the most user-friendly path through the classification so that they can quickly find the content they want.
- Ensure readers always know where they are on the site.
- Allow readers to move quickly and logically through the web site.
- Give readers the proper context of the document they are reading.
- Highlight parts of the classification for the reader that the organization wants to promote".

In the article "*Designing Your Site's Navigation*", van Welie (no date), listed a variety of navigational forms that have been developed to improve website navigation.

- Top navigation is a horizontal "menu" at the top of all pages and stays unchanged when browsing through the site.
- Left navigation, also called vertical navigation; splits webpages in at least two columns where the left column is used to place the navigation tools.

- Top-left navigation deals with three and four level hierarchy structure. Top navigation is used for items of level one hierarchy while left navigation is used for items of level two and three hierarchy.
- Breadcrumb navigation displays a sequence of links in the hierarchical website that lead from the first page to the current webpages. In that way breadcrumb navigation shows the location of the current webpage in the website.
- With split navigation, navigating the first levels is separated from navigating the remaining levels.
- Matrix navigation is for the situation when some pages can "fit" in more than one place in the information structure. Those pages are accessible through cross-links. When users follow the cross link, they are "transferred" to the other branch of the hierarchy.
- Horizontal navigation is for the situation when some pages are very long and it does not make sense to structure them hierarchically. Navigation of these pages is split up in several pages as page one, page two and so on.

Many recent surveys, however, demonstrated the necessity to improve web navigation.

- "Research by User Interface Engineering, Inc. showed that people could not find the information they were seeking on a Web site approximately *60%* of the time" (Usability Gov, n.d.).

- "In Jared Spool's study of fifteen large commercial sites, users could only find information *42%* of the time even though they were taken to the correct home page before they were given the tasks" (Nielsen, 1998).
- Studies by Forrester Research estimated that approximately *50%* of potential sales were lost from a site as users could not find information and that *40%* of users did not return to a site when their first visit was a negative experience (Nielsen, 1998).
- "A study by Zona Research found that *62%* of Web shoppers had given up looking for the item they wanted to buy online (and *20%* had given up more than three times during a two-month period)" (Nielsen, 1998).

"Web users are notoriously impatient and fickle" (Murray and Costanzo, 1999). "Studies of user behavior on the Web also found a low tolerance for difficult designs or slow sites" (Nielsen and Norman, 2000). People do not want to wait. If they cannot grasp the functionality of the site immediately after scanning the home page for a few seconds at most, they will quickly go somewhere else and likely not return (Nielsen and Norman, 2000).

"Since over half of all users often arrive at pages through search or other means that bypass the higher-level navigation pages, it is necessary to provide a path back to these higher levels" (Nielsen, 2000). Data from 75 leading e-commerce sites, collected in May 2002, showed *45%* of pages included breadcrumbs for navigation (Web Design Practices, 2004). Breadcrumbs are a list of links to previous visited webpages or webpages of upper level hierarchy. According to Nielsen (2000), breadcrumb navigations serve two purposes:

- "The context of the current page (how it is nested) allows users to interpret the page better (you don't just know that you are looking at product 354, you also know that it belongs to the widget product family)".
- "The links allow users to go directly to a higher level of the site in case the current page is not what they want, but they do want something similar".

Breadcrumbs have become an important navigational tool of the WWW, but there has been little investigation and research regarding their "precise concepts and terminology in order to effectively use breadcrumbs in different situations" (Instone, 2003).

2.2 Breadcrumbs

The term "breadcrumb" is based on the Grimm's fairy tale, Hansel and Gretel[1]. Hansel left a trail of breadcrumbs as a strategy to find his way back out of the forest. Internet users often need to go back to a previously visited page.

Breadcrumbs are a list of links separated by some characters or graphics (Instone, 2003). The purpose of breadcrumbs is two fold: "to convey information to the users (about the site structure or the path they have taken), and to give users a way to select links from the breadcrumbs (in order to go up in the site hierarchy or to retrace their steps)" (Instone, 2003).

[1] Source: <URL: http://www.fln.vcu.edu/grimm/haenseleng.html>

Breadcrumbs are distinguished into three kinds, location breadcrumbs, path breadcrumbs, and attribute breadcrumbs. Location breadcrumbs show readers where the current webpage is within the hierarchy of the current website. As such, they are rather like route markers on a highway. Location breadcrumbs are very common in the following presentation: First Element > Second Element > Third Element > Last Element

The first element usually represents the site home page. The second element is a sub-directory of the first element, and the third element is a sub-directory of the second element. The last element usually represents the name of the current page. Real examples of location breadcrumbs are found from websites such as Yahoo[2] (Figure 1).

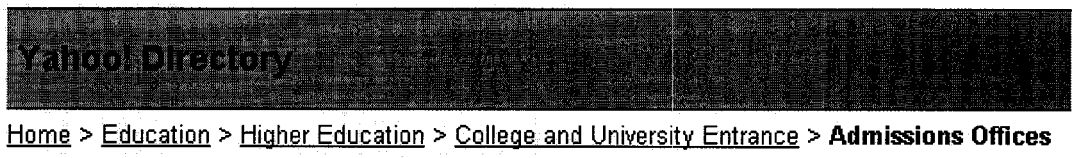

Figure 1: An example of location breadcrumbs

Path breadcrumbs show the particular paths that users have taken to the current webpage. "The same content from the site can be presented with different breadcrumbs because users can take different routes" (Instone, 2003). Unlike location breadcrumbs and path breadcrumbs that represent the location or path to the current webpage, "attribute breadcrumbs use breadcrumb-like navigational features as meta-information to describe components of the site. The most common examples are e-commerce site that use

[2] Source: <URL:http://www.yahoo.com/>

breadcrumbs as a type of extended keyword to convey product meta-information, such as subject, price, category, style, and brand." (Instone, 2003)

Throughout the rest of the document, breadcrumbs generally mean location breadcrumbs if not specifically indicated.

2.3 Related Work

Recent studies about user navigational patterns and breadcrumbs were reviewed. Studies indicated that Internet users often needed to go back to previously visited pages, and breadcrumbs provided potential benefits to serve this purpose.

In a study of user revisitation patterns in the WWW, Tauscher and Greenberg (1997) found that *58%* of an individual's pages were revisits. "While many pages were revisited, users continually incorporated new pages into their repertoire at a regular rate. People tended to revisit pages just visited, accessed only a few pages, frequently browsed in very small clusters of related pages, and generated only short sequences of repeated URL paths" (Tauscher and Greenberg, 1997). Their findings fell in the general rule of short memory span (Miller, 1956), and explained the needs of providing a back-path to retrace users route ("back" consisted of *30%* of all navigation actions).

Lazar and Eisenbrey (2000), investigated whether navigation bars (breadcrumbs) were truly useful or not. Sixty-seven subjects were recruited for the experiment. Results of the

experiment revealed that navigation bars did make a difference. On average, it took about *60* seconds less time to navigate a site with navigation bars than without. Result of subjective survey showed that many people used the navigation bars frequently (when they were available) and did not mind having a navigation bar around.

Lida, Hull, and Pilcher (2001) studied "breadcrumb navigation" to evaluate participants' navigational strategies, user satisfaction, and general preference for two sites that include "breadcrumbs" — Google Directory, a search site, and Office Max, an e-commerce office supply site. "The average amount of breadcrumb usage was low. Not all participants understood the function of breadcrumbs. Even regular breadcrumb users were not found to be more efficient than users who did not use the breadcrumbs. Participants preferred using other navigational methods to find information, such as the back button, left or top menu bars, and searching" (Lida, Hull, and Pilcher, 2001).

Rogers and Chaparro (2003) completed a further study on the effectiveness of breadcrumb navigation. The study examined breadcrumb usage by evaluating the following research questions:

- Do users choose to use breadcrumbs as a navigational tool?
- Does breadcrumb usage improve navigational efficiency?
- Does the location of the breadcrumb trail on a page effect usage?
- Does a breadcrumb trail aid the user's mental model of the site structure?

The study found that

- *6%* of the page clicks came from the breadcrumbs
- *40%* of the participants used the breadcrumb trail
- Breadcrumb usages were lower than the main navigation bar, the back button, and embedded links
- The Back button was used far less often by users who followed the breadcrumb trails
- Breadcrumb trails positioned under the page title are more effective than breadcrumb trails positioned elsewhere

Continuing Rogers and Chaparro's study, Hull (2004) investigated the effects of "mere exposure" and training on breadcrumb usage. Thirty-nine college students volunteered for this study. Participants were randomly assigned to one of three conditions. Condition I participants were shown the use of the breadcrumb trail twice by the experimenter prior to testing. Condition II participants served as the mere exposure group and were shown the same usage of the breadcrumb trail as participants in Condition I. However, this group was given no explanation or instruction to use the breadcrumb trail as in Condition I group. Condition III participants received no exposure, explanation, or instruction on the breadcrumb trail. Findings from the experiment indicated that "brief training on the benefits of breadcrumb usage resulted in more efficient search behavior" (Hull, 2004). "On average, those participants who received both exposure and instruction completed all

tasks much faster than participants receiving only exposure (*3* min) and those receiving no exposure or instruction (*4* min)" (Hull, 2004).

Chapter 3 Development of Menu Breadcrumbs

TWO roads diverged in a yellow wood,
And sorry I could not travel both
And be one traveler, long I stood
And looked down one as far as I could
To where it bent in the undergrowth
...
I took the one less traveled by,
And that has made all the difference.
— The Road Not Taken (Robert Frost, 1920)

Our goal in this study was to find ways to help users find information in hierarchically structured websites. We anticipated that users' goals would be to find certain pieces of information. To achieve those goals, the users will navigate various pages of different websites. Users, however, often do not know exactly where to go to find the information they are looking for. Most likely, this is because they have never used the website before, or they have used the site but are in an unfamiliar part of it. In either circumstance, the users need to assess the content of the webpage to determine whether they have found the information to fulfill their goals, whether the webpage leads to another page that is more likely to have the information, and whether there is likely more appropriate (e.g. specific) information in another page. It is therefore, not surprising that when carrying out these multiple tasks, users become lost when searching information, or require much more time to locate that information than one would prefer.

We speculate that breadcrumbs can help users in three specific ways. (*1*) Breadcrumbs can keep users from being lost by showing them where they are in relation to the local

organization of the websites. (*2*) Breadcrumbs can keep users focused on their goal by reminding them the context they are searching. (*3*) In some circumstances, breadcrumbs can help users backtrack quickly when they realize that they are in a wrong place of the website, but not always (e.g. if users followed a link from a search engine, or a cross-link from a different part of the website). From these three specific ways, we conceived of a new sub-type of breadcrumb: the menu breadcrumb.

Plain location breadcrumbs show users the trail of links leading to their current location, which can help users to backtrack and to get a sense of the local part of the website. We speculated that some forms of look ahead might also be useful. We developed a novel extension of existing breadcrumbs —— menu breadcrumbs. The conception is similar to a map of the current neighborhood shown in an automobile screen. In addition to providing a list of links about the position of a current webpage within the site hierarchy, menu breadcrumbs provide pop-up menus of sub-directories available from the webpages represented by the breadcrumbs when users move their mice over the breadcrumbs. A picture of menu breadcrumbs that we developed is showed in Figure 2. Menu breadcrumbs not only allow users to know where their current locations are, the technique also provides users choices of where they could go (one-step further) at each intersection along the position path. We expect that menu breadcrumbs will provide users with more precise information of the site structure and encourage them to use the technique more frequently.

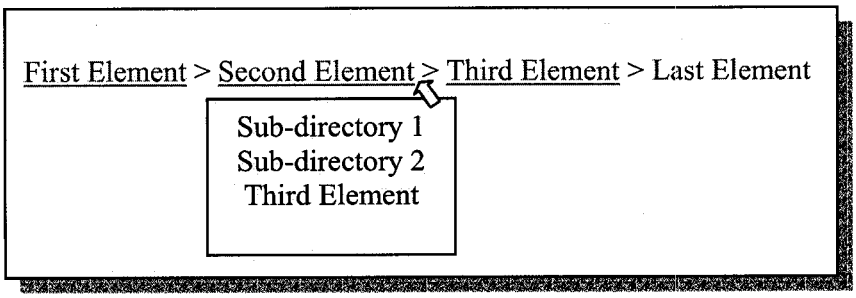

Figure 2: Design of Menu Breadcrumbs

Bowler, Ng, and Schwartz (2001) explored a similar technique, which they called navigational bars. The goal of their experiment was to determine the effectiveness of the selection list navigation bar (an innovation to the standard navigation bar). Figure 3 shows a snapshot of the selection list navigational bar. In their experiment, eighteen subjects were recruited to search answers to multiple-choice questions using control (single link back to the home page), standard (a list of links back to each page in the path), and selection list (a list of links to each page in the path and each of their siblings) styles of navigation bars. They found that after completing the first five questions, subjects could significantly reduce the number of page loads necessary to find an answer using the selection lists, but could not significantly reduce the amount of time necessary.

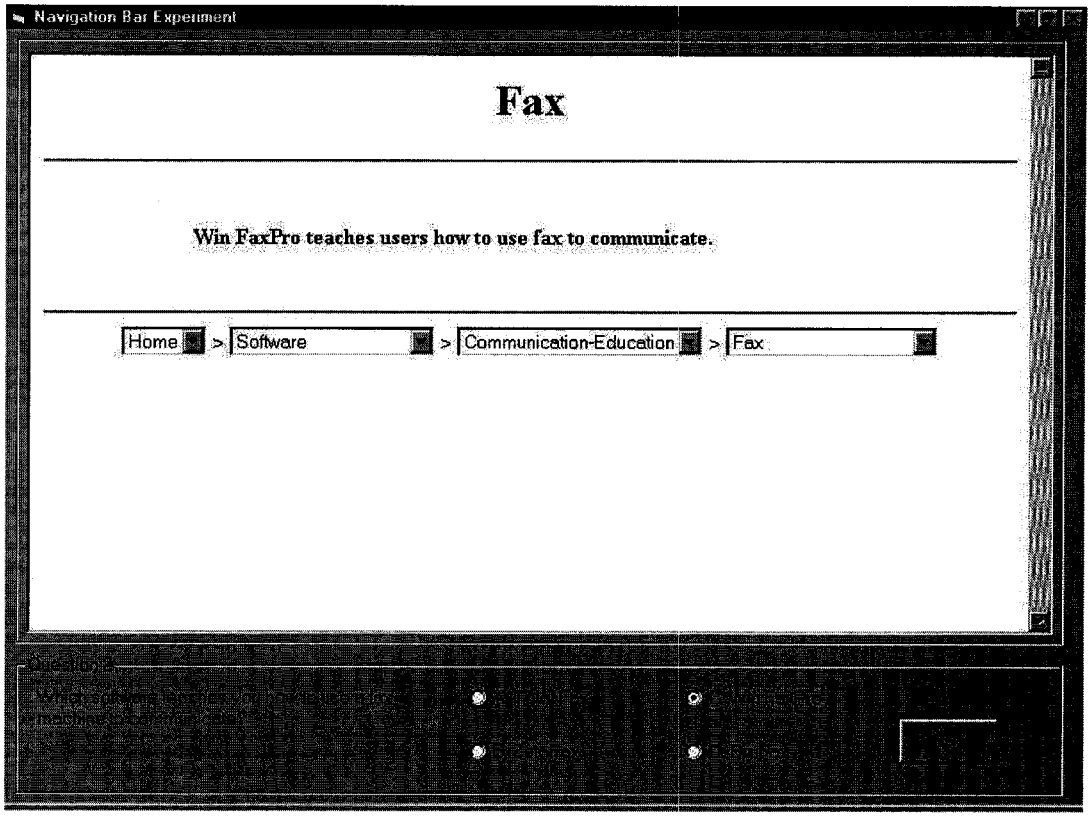

Figure 3: Snapshot of selection list navigational bar

Chapter 4 Experimental Design

The current study explored location breadcrumbs in the context of humans searching for online information. The aim of the study was to investigate whether navigating with menu breadcrumbs was more beneficial than navigating with non-menu breadcrumbs based on the following measures: speed, frequency of using breadcrumbs, P. A. Smith's (1986) lostness, and satisfaction.

4.1 Subjects

Experimental subjects were recruited through campus posters and department email lists (Appendix B). Forty subjects participated (with no compensation) in the experiment. They were all university students and most of them had extensive experience with the Internet. Table 1 provides general description of the participants.

Table 1: General description of the participants

		N	Percentage (N=40)
Gender	Male	26	65%
	Female	14	35%
Age	≤20	7	17.5%
	21 – 25	13	32.5%
	26 – 30	12	30%
	≥31	8	20%
Time Online	< 2 hrs a week	1	2.5%
	2 – 5 hrs a week	6	15%
	6 – 10 hrs a week	5	12.5%
	> 10 hrs a week	28	70%
Education Background	CS and Engineering	30	75%
	Business and Management	4	10%
	Science	4	10%
	Arts and Social Sciences	2	5%

4.2 Websites

Experimental websites were adapted from the English edition of the Canadian Government Web Directory[3]. This website is a hierarchical directory of government services. At the top level are three sub-sites: Services for Canadians, Services for Non-Canadians, and Services for Canadian Businesses (Figure 4). The first two of those sub-sites were downloaded and edited on a local machine into two webpage formats; one was linked with menu breadcrumbs and the other one with non-menu breadcrumbs. Figure 5 shows the structure of the Canadian site, Figure 6 the structure of the Non-Canadian site. Both the Canadian site and the non-Canadian site used in this experiment had six levels of hierarchy (from the home page to the lowest leaf pages). The Canadian site had 254 leaf pages. The non-Canadian site had 220 leaf pages. Six target pages were drawn from

[3] Source: <URL:http://www.gc.ca/>

93 leaf pages at the lowest level from the Canadian site; six target pages were drawn from 92 leaf pages at the lowest level from the non-Canadian site. Table 2 shows detail comparison of the Canadian site and non-Canadian site.

Table 2: Comparison of the Canadian site and non-Canadian site

	Level 2		Level 3		Level 4		Level 5		Level 6
Home	# Cat	# Leav	# Cat	# Leav	# Cat	# Leav	# Cat	# Leav	# Leav
Cdn	4	19	19	87	22	113	28	93	93
Non- Canadian	4	20	20	93	19	81	21	92	92

Cat: Categories, Leav: Leaves

The experimental website was much like many directory websites such as the Yahoo site that did not include any content (other than titles, directory links, and breadcrumbs) for the web pages at upper levels. At the lowest level, only titles, breadcrumbs, and a piece of non-navigational content were included. The reason is to make conditions similar for all groups of subjects. Otherwise, some subjects would need to read more texts than other subjects. The non-navigational content of each target web page simply indicated that the leaf webpage was an answer to related questions (see Figure 8). The non-navigational content of each non-target webpage simply indicated that the leaf webpage was an end of the website (see Figure 7).

Figure 4: Canadian Government Web Site

"Information on this site has been posted with the intent that it be readily available for personal and public non-commercial use and may be reproduced, in part or in whole and by any means, without charge or further permission from Public Works and Government Services Canada". [4]

[4] Source: <URL:http://www.gc.ca/>

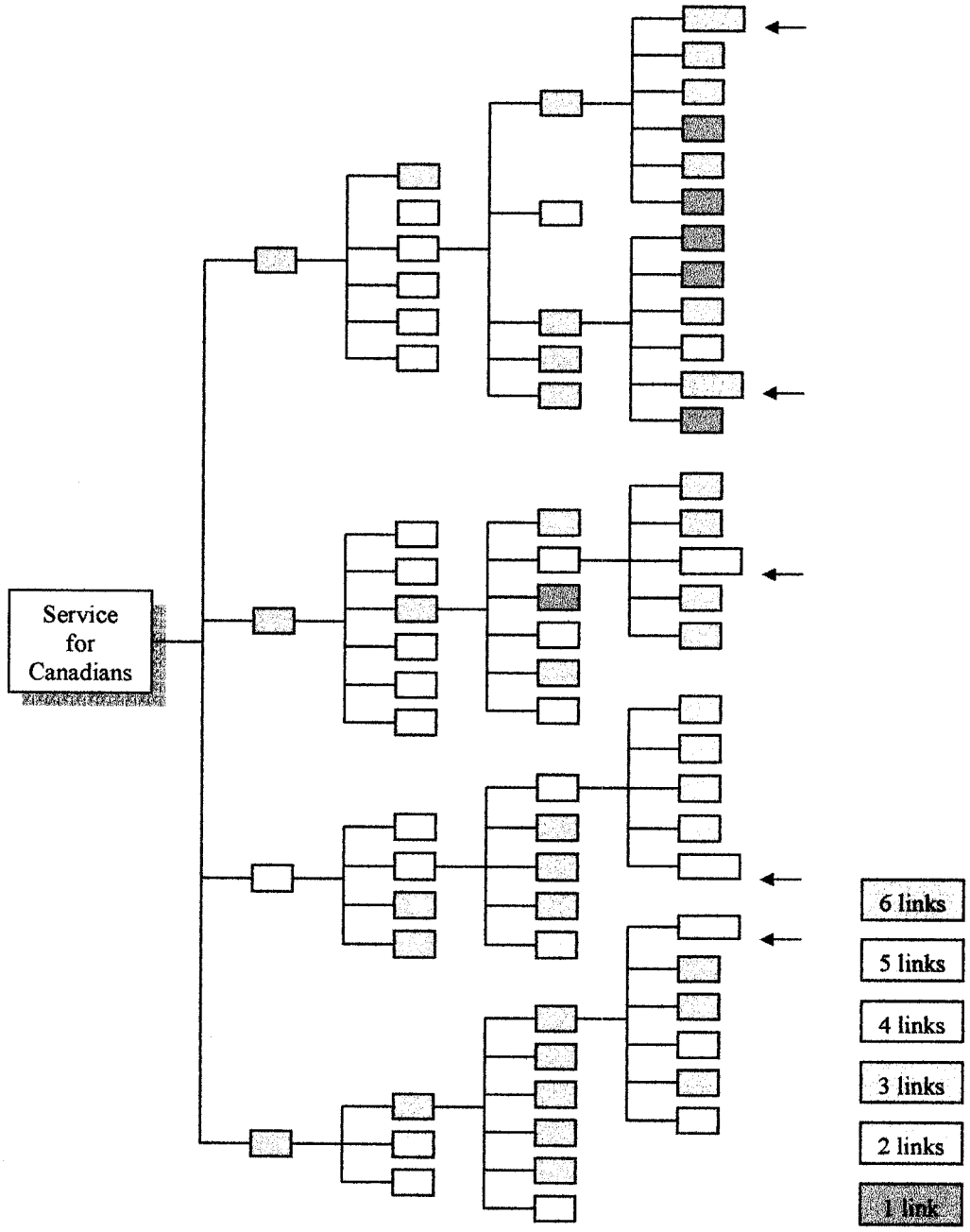

Figure 5: Structure of the site for Canadians

Color indicates the number of links. The wider boxes, indicated with arrows, show where the target web pages resided for our study. Six out of 254 leaf pages were target webpages.

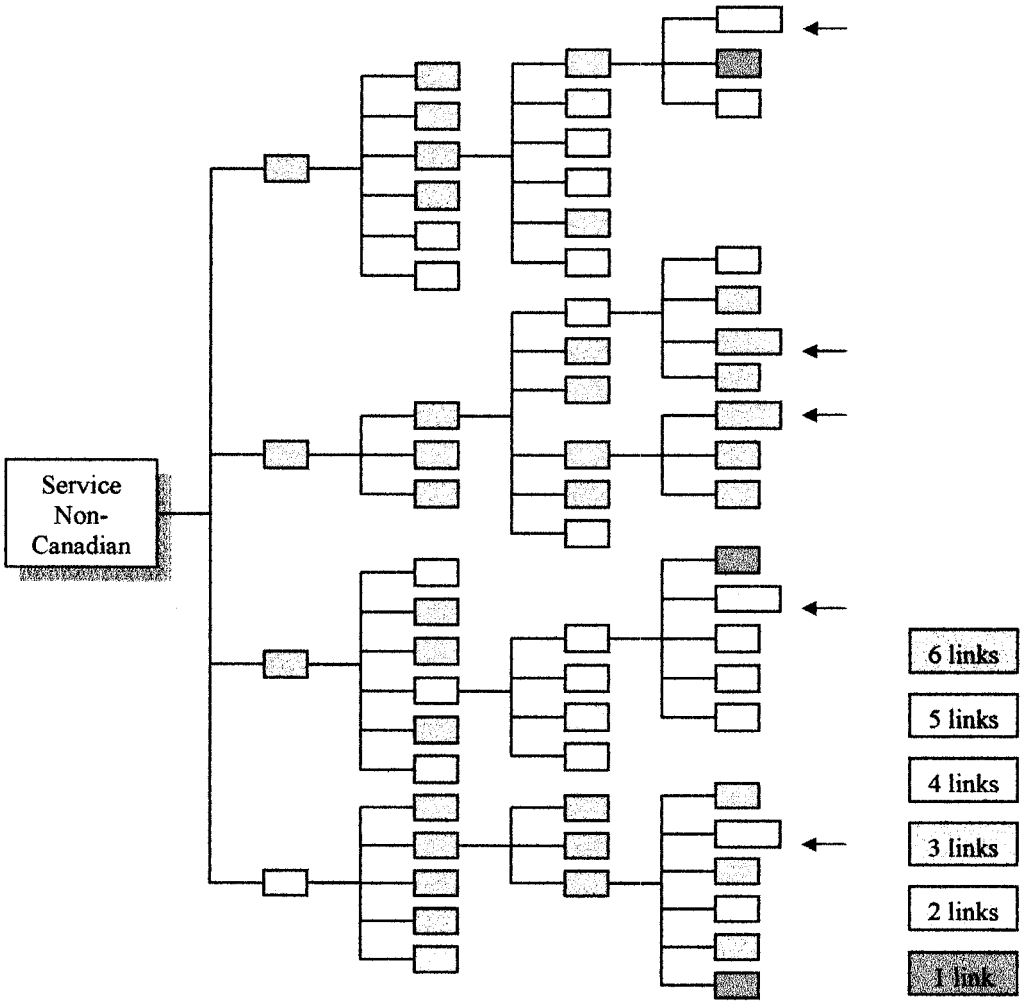

Figure 6: Structure of the site for Non-Canadians

Color indicates the number of links. The wider boxes, indicated with arrows, show where the target web pages reside for our study. Six out of 220 leaf pages were target webpages.

4.3 Breadcrumbs

Breadcrumbs were displayed into two formats. The first format (non-menu breadcrumbs or plain breadcrumbs), was similar to those found on most websites (Figure 7). The second format (menu breadcrumbs), was identical to the first format except that there were pop-up lists showing sub-directories available from the webpages represented by the menu breadcrumbs (Figure 8).

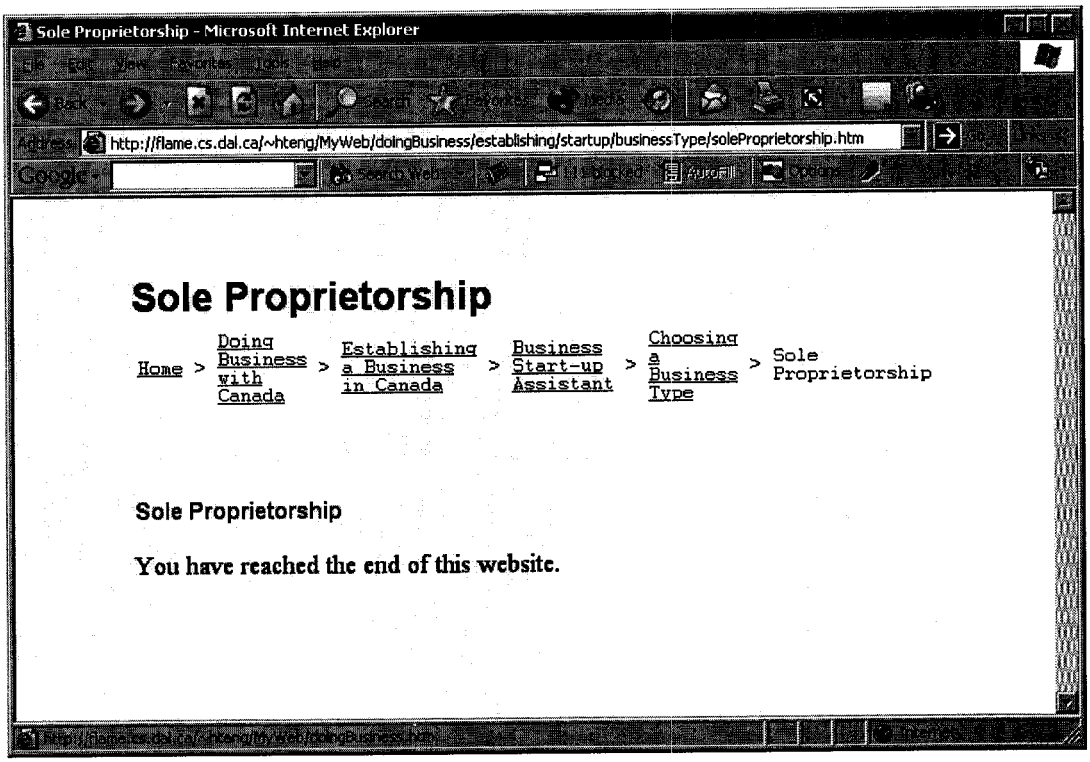

Figure 7: Non-Menu Breadcrumb

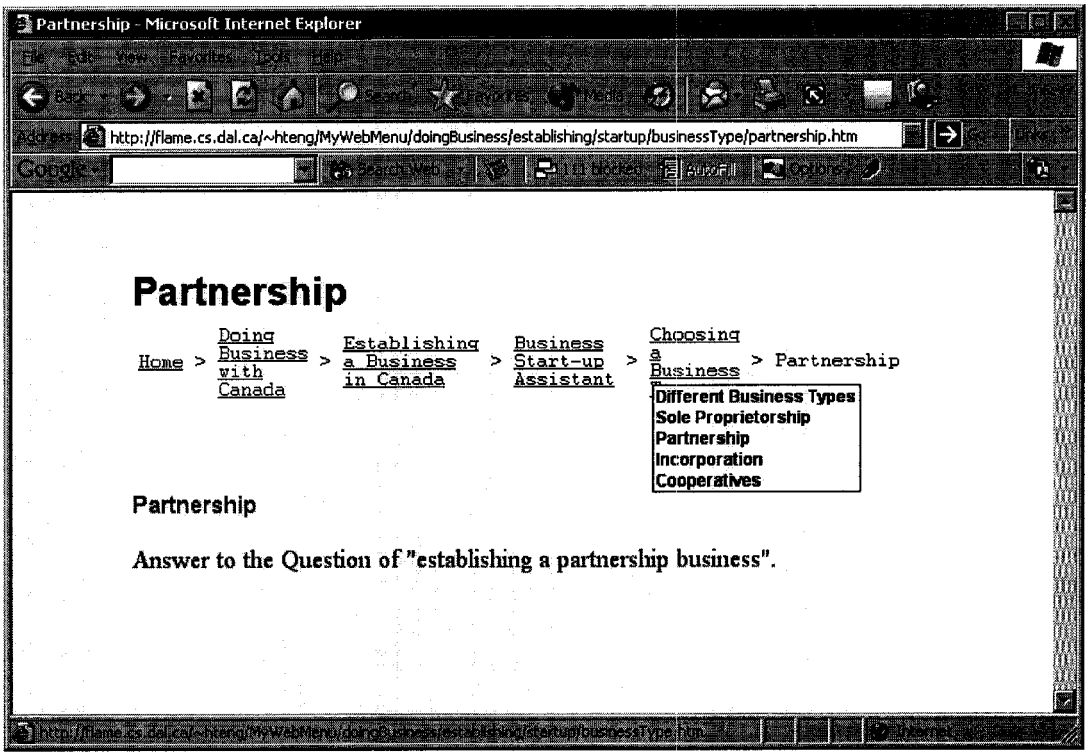

Figure 8: Menu Breadcrumb

4.4 Cross-over Design

The study used a mix of within and between subject designs. Each participant was requested to complete two sequences of information seeking activities using two treatments. The treatment was a mixture of breadcrumbs and websites. Subjects navigated with one type of breadcrumbs using one site in the first session and then navigated with the other type of breadcrumbs using the other site in the second session. Forty subjects were randomly assigned to one of the participant groups, *10* for each group in Table 3.

Table 3: Mixture of breadcrumb type and website

Participant Group	Session	
	First	Second
1	CM	NCNM
2	NCNM	CM
3	CNM	NCM
4	NCM	CNM

CM: Services for Canadians with Menu Breadcrumbs
NCNM: Services for Non-Canadians with Non-Menu Breadcrumbs
CNM: Services for Canadians with Non-Menu Breadcrumbs
NCM: Services for Non-Canadians with Menu Breadcrumbs

4.5 Experimental Activities

No practice was given to participants before the experiment. First, this was an initial study of menu breadcrumbs and we were not focused on the learning effect of using the technique. Second, despite the fact that many websites have included breadcrumb navigation, a study by Lida, Hull, and Pilcher (2001) showed most Internet users did not fully understand the functionality of breadcrumbs. We expected that our novel extension of existing breadcrumbs — menu breadcrumbs would provide a better sense of site structures and that the functionality of the technique would be easily grasped when no practice was provided.

To begin the experiment, participants were requested to complete a preliminary questionnaire (Appendix C) in order to measure their computer literacy and knowledge of the information from governmental departments and agencies.

In the main part of the experiment, participants performed five information seeking tasks using each of the two treatments. Instructions for all these activities were outlined in an

instruction sheets (Appendix A) and passed to participants before the experiment. The five tasks were:

(1) Finding a path from the home page to a leaf page (Page A)
(2) Finding a path from Page A to another leaf page (Page B) which shares a non-root parent with Page A (see Figure 9)
(3) Answering a question having a keyword from directory tree indicating a partial path to the location that contains the answer
(4) Answering a question with no path information to the location that contains the answer
(5) Answering a question requiring comparison of two web pages which share a non-root parent

Before each task, participants were asked to provide their knowledge about the task and time expected to find the answer. A post-task question was also included to inquire participants' feeling about the difficulty of the task they just completed.

After each session, participants completed an evaluation questionnaire about their satisfaction toward using breadcrumbs.

Finally, a modified end user satisfaction model from Chin and Lee (no date) was presented to participants. The model consisted of the questions about initial instruction,

content of the website, accuracy, ease of use, ease of navigation, speed, and overall satisfaction.

The full list of questions is in Appendix C. Answers to all these questions other than the questions in the preliminary questionnaire were adapted to use 4-point and 5-point Likert Scales.

The average time for participants to complete all these activities was 20 to 40 minutes. During the experiment, participants were free to withdraw at any time.

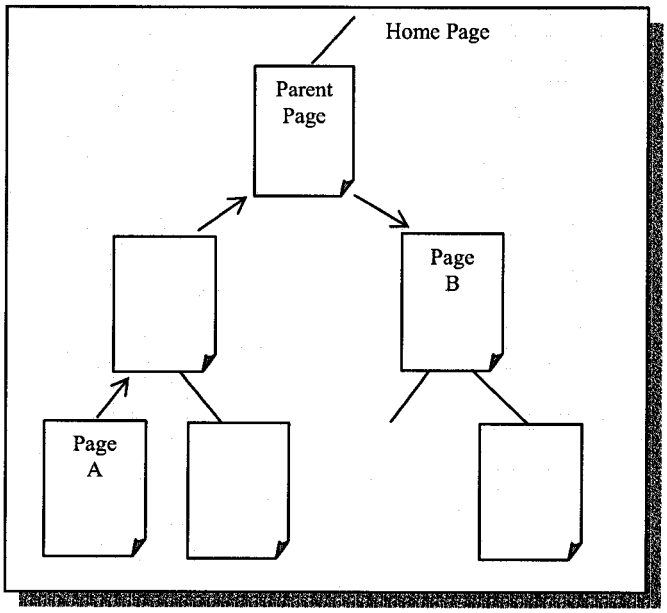

Figure 9: Path from page A to page B

4.6 Data Acquisition Tools

To collect data (in particular to observe participants' interaction with the web browser back and forward buttons) a customized web-based usability testing service known as Uzilla was employed. "Uzilla uses a client and server architecture with a custom web browser, application server, and relational database backend" (Uzilla, 2003). The web browser that participants worked with was a Mozilla based application that could be downloaded to a local computer. Test activities and questionnaires were configured in a web application using browsers. Users' online behavior data and responses to questionnaires were collected, aggregated, and stored in a relational database for future analysis.

4.7 Study Data

In order to observe whether participants made use of breadcrumbs and their effectiveness of using breadcrumbs, the following data were collected:

- Time to complete tasks
- Sequence of links (including the back and forward buttons) followed by participants
- Participants' reported satisfaction

The collected data were used to compute the following measures:

- Speed
- Frequency of Breadcrumb Clicks
- P. A. Smith's Lostness (Smith, 1986)
- Satisfaction

ANOVA analyses were applied to determine whether different breadcrumb techniques produced significant differences.

Chapter 5 Hypotheses and Variables

5.1 Hypotheses

The null hypothesis was that using different breadcrumb techniques would produce equal effect on subjects' performance under all levels of experimental treatments. The alternative hypothesis was that there would be a significant difference. A comparison was made between the two types of breadcrumbs to determine whether one type was more beneficial to users than the other.

5.2 Variables

5.2.1 Independent Variables

The independent variables of the experiment are: (*1*) session, (*2*) site, and (*3*) breadcrumb. These variables were manipulated in two ways.

(*1*) Session had two levels: session one and session two. Subjects completed session one before starting session two. Because session one and session two were associated with different sites and using different breadcrumb techniques for navigation, we assumed that session would have no significant effect.

(*2*) Site was divided into a site for Canadians and a site for non-Canadians. Each site was linked to one type of breadcrumbs. The sites were sub-sites of a coherent site with similar structures, complexity, and other relevant aspects. The performance of subjects navigating one site was assumed equal to the performance navigating the other site.

(*3*) Two kinds of breadcrumbs were also presented: menu breadcrumbs, and non-menu breadcrumbs. We were interested in whether navigating with different breadcrumb techniques would produce the same or different performance.

5.2.2 Dependent Variables

Once the manipulation was carried out, four outcomes of subjects' performance were measured to investigate the effect of the independent variable.

(*a*) Speed

Speed was the time that subjects spent to complete a task. Subjects were likely to complete the experiment with different amount of time.

(*c*) Frequency of breadcrumb clicks

If breadcrumbs had more advantages than the *back* button, we assumed that subjects would click the breadcrumbs more frequently for navigation. The frequency of breadcrumb clicks was measured as the ratio of the difference between the number of breadcrumb clicks and the number of *back* button clicks compared with the total number of page visited.

$$F = \frac{C_n - C_b}{S}$$

Where F increases as frequency of breadcrumb clicks increases

C_n: the number of breadcrumb clicks (navigational clicks)

C_b: the number of *back* button clicks (browser clicks)

S: total number of pages visited

If F was less than zero, subjects were more dependent on the back buttons than breadcrumbs. If F was greater than zero, subjects were more dependent on breadcrumbs.

(*d*) P.A. Smith's Lostness (Smith, 1986)

Lostness was the scale of the number of different and total pages visited compared with the number of pages required to complete a task.

$$L = \sqrt{((N/S-1)^2 + (R/N-1)^2)}$$

Where L increases as lostness increases

N: the number of different pages visited

S: total number of pages visited

R: the number of pages required to be visited to complete a task

According to P.A. Smith's usability study, "values of L less than *0.4* corresponded to experimental subjects who were not lost and where L was greater than *0.5* the subjects were definitely lost." (Smith, 1986)

(*e*) Satisfaction

Subjects were given a questionnaire to gather information about their satisfaction with the breadcrumb techniques presented. Higher scores indicated better satisfaction. The scores collected from the questionnaire helped us better understand how useable the breadcrumbs were.

Chapter 6 Results

6.1 Introduction

To investigate if individual experiment manipulations or combinations of them (*SS, ST, BT, ST* × *BT, SS* × *ST, SS* × *BT*, or *SS* × *ST* × *BT*) affected subjects' performance, factorial ANOVAs (Multivariate ANOVA followed by Univariate ANOVA using SPSS for Windows) were conducted. Multivariate ANOVA is used to study the effect of one independent variable on several dependent variables. Univariate ANOVA examines the effect of several independent variables on one dependent variable. Results of the MANOVA are shown first. The UANOVA was performed on three levels for the whole experiment and for each session respectively. The first level compared the subjects' overall performance based on *SS*, *BT*, and *ST* exclusively. The second level looked at the interaction of *ST* × *BT*, *SS* × *ST* and *SS* × *BT*. The final level investigated the interaction of these three, i.e. *SS* × *ST* × *BT*. In addition to reporting statistical significance ($p < 0.05$), we report marginal significance ($0.05 < p < 0.10$), and effect size —— R-squared (r^2). McBurney and White, (2004) suggest that many experimenters might prefer to make a type I rather than a type II error. We also included marginally significant results, p tied to *0.10*, because we wanted to further investigate potentially promising directions of our research. R-squared (r^2) is a measure of how much of the variability in the outcome is accounted for by the independent variables. Most often in applied research such as Human-Computer Interaction, effect size is more appropriate than statistical significance (Landauer, 1997). An accepted principle for interpreting R-squared were developed by

Mcgrenere, Backer, and Booth (2002): .01 for a small effect, .06 for medium, and .14 for large. Table 4 presents the descriptive statistics for each dependent variable.

Table 4: Descriptive Statistics of Dependent Variables

	N	Range	Min	Max	Mean	Std. Error	Std.	Variance
Speed	80	409.934	23.234	433.168	145.300	10.084	90.195	8135.080
Frequency	80	.877	-.446	.431	.071	.032	.285	.081
Lostness	80	.991	.327	1.318	.710	.020	.182	.033
Satisfaction	77	3.000	2.000	5.000	3.743	.070	.616	.380
Valid N	77							

6.2 MANOVA

Table 5 shows the main results of the MANOVA. All values listed in the *Signif.* column are greater than *0.05*. No between-group variance was observed. However, the values corresponding to *SS* ($p = 0.105$) and *SS* × *BT* ($p = 0.107$) may have marginal significance which would indicate that session and the interaction between session and breadcrumb type may have slightly affected subjects' overall performance.

Exploring the possible effect of session further, we evaluated each session independently. These analyses revealed a significant effect of navigating with different breadcrumb techniques ($p = 0.049$) in the first session. No significant difference was found in the second session. Table 6 shows the results for session one, Table 7 the results for session two.

Table 5: Multivariate Tests [b]

Effect		Value	F	Hypothesis df	Error df	Signif.
Intercept	Pillai's Trace	.987	992.259 [a]	5.000	65.000	.000
	Wilks' Lambda	.013	992.259 [a]	5.000	65.000	.000
	Hotelling's Trace	76.328	992.259 [a]	5.000	65.000	.000
	Roy's Largest Root	76.328	992.259 [a]	5.000	65.000	.000
BT	Pillai's Trace	.091	1.295 [a]	5.000	65.000	.277
	Wilks' Lambda	.909	1.295 [a]	5.000	65.000	.277
	Hotelling's Trace	.100	1.295 [a]	5.000	65.000	.277
	Roy's Largest Root	.100	1.295 [a]	5.000	65.000	.277
SITE	Pillai's Trace	.123	1.819 [a]	5.000	65.000	.121
	Wilks' Lambda	.877	1.819 [a]	5.000	65.000	.121
	Hotelling's Trace	.140	1.819 [a]	5.000	65.000	.121
	Roy's Largest Root	.140	1.819 [a]	5.000	65.000	.121
SS	Pillai's Trace	.128	1.910 [a]	5.000	65.000	.105 *
	Wilks' Lambda	.872	1.910 [a]	5.000	65.000	.105 *
	Hotelling's Trace	.147	1.910 [a]	5.000	65.000	.105 *
	Roy's Largest Root	.147	1.910 [a]	5.000	65.000	.105 *
SITE × BT	Pillai's Trace	.068	.946 [a]	5.000	65.000	.458
	Wilks' Lambda	.932	.946 [a]	5.000	65.000	.458
	Hotelling's Trace	.073	.946 [a]	5.000	65.000	.458
	Roy's Largest Root	.073	.946 [a]	5.000	65.000	.458
SS × SITE	Pillai's Trace	.027	.360 [a]	5.000	65.000	.874
	Wilks' Lambda	.973	.360 [a]	5.000	65.000	.874
	Hotelling's Trace	.028	.360 [a]	5.000	65.000	.874
	Roy's Largest Root	.028	.360 [a]	5.000	65.000	.874
SS × BT	Pillai's Trace	.127	1.897 [a]	5.000	65.000	.107 *
	Wilks' Lambda	.873	1.897 [a]	5.000	65.000	.107 *
	Hotelling's Trace	.146	1.897 [a]	5.000	65.000	.107 *
	Roy's Largest Root	.146	1.897 [a]	5.000	65.000	.107 *
SS × SITE × BT	Pillai's Trace	.046	.630 [a]	5.000	65.000	.677
	Wilks' Lambda	.954	.630 [a]	5.000	65.000	.677
	Hotelling's Trace	.048	.630 [a]	5.000	65.000	.677
	Roy's Largest Root	.048	.630 [a]	5.000	65.000	.677

a) These *F*-values are exact statistics
b) Design: Intercept+BT+SITE+SS+SITE × BT+SS × SITE+SS × BT+SS × SITE × BT

Table 6: Multivariate Tests [b] in Session One

Effect		Value	F	Hypothesis df	Error df	Signif.
Intercept	Pillai's Trace	.990	743.888 [a]	4.000	31.000	.000
	Wilks' Lambda	.010	743.888 [a]	4.000	31.000	.000
	Hotelling's Trace	95.986	743.888 [a]	4.000	31.000	.000
	Roy's Largest Root	95.986	743.888 [a]	4.000	31.000	.000
BT	Pillai's Trace	.258	2.701 [a]	4.000	31.000	.049 **
	Wilks' Lambda	.742	2.701 [a]	4.000	31.000	.049 **
	Hotelling's Trace	.349	2.701 [a]	4.000	31.000	.049 **
	Roy's Largest Root	.349	2.701 [a]	4.000	31.000	.049 **
SITE	Pillai's Trace	.191	1.832 [a]	4.000	31.000	.148
	Wilks' Lambda	.809	1.832 [a]	4.000	31.000	.148
	Hotelling's Trace	.236	1.832 [a]	4.000	31.000	.148
	Roy's Largest Root	.236	1.832 [a]	4.000	31.000	.148
BT × SITE	Pillai's Trace	.085	.722 [a]	4.000	31.000	.583
	Wilks' Lambda	.915	.722 [a]	4.000	31.000	.583
	Hotelling's Trace	.093	.722 [a]	4.000	31.000	.583
	Roy's Largest Root	.093	.722 [a]	4.000	31.000	.583

a) Exact statistic
b) Design: Intercept+BT+SITE+BT × SITE

Table 7: Multivariate Tests [b] in Session Two

Effect		Value	F	Hypothesis df	Error df	Signif.
Intercept	Pillai's Trace	.981	412.747 [a]	4.000	32.000	.000
	Wilks' Lambda	.019	412.747 [a]	4.000	32.000	.000
	Hotelling's Trace	51.593	412.747 [a]	4.000	32.000	.000
	Roy's Largest Root	51.593	412.747 [a]	4.000	32.000	.000
BT	Pillai's Trace	.070	.605 [a]	4.000	32.000	.662
	Wilks' Lambda	.930	.605 [a]	4.000	32.000	.662
	Hotelling's Trace	.076	.605 [a]	4.000	32.000	.662
	Roy's Largest Root	.076	.605 [a]	4.000	32.000	.662
SITE	Pillai's Trace	.073	.628 [a]	4.000	32.000	.646
	Wilks' Lambda	.927	.628 [a]	4.000	32.000	.646
	Hotelling's Trace	.078	.628 [a]	4.000	32.000	.646
	Roy's Largest Root	.078	.628 [a]	4.000	32.000	.646
BT × SITE	Pillai's Trace	.043	.363 [a]	4.000	32.000	.833
	Wilks' Lambda	.957	.363 [a]	4.000	32.000	.833
	Hotelling's Trace	.045	.363 [a]	4.000	32.000	.833
	Roy's Largest Root	.045	.363 [a]	4.000	32.000	.833

a) Exact statistic
b) Design: Intercept+BT+SITE+BT × SITE

6.3 Speed

Table 8 provides the descriptive statistics of speed for all treatments in the experiment. In the analysis of the number of seconds that subjects took to complete the whole experiment, a marginally significant *2*-way interaction effect was observed between breadcrumb type and session ($F\ (1, 72) = 3.508, p = 0.065, r^2 = 0.014$) (see Table 9 and Figure 10).

Exploring this interaction effect further, no significant difference in terms of speed for the two breadcrumb types was found. Table 10 shows the results for session one, ($F\ (1, 36) = 1.477, p = 0.232, r^2 = 0.039$). Table 11 the results for session two, ($F\ (1, 36) = 2.086, p = 0.157, r^2 = 0.054$).

Table 8: Descriptive Statistics Speed

Dependent Variable: Time (Speed)

Session	Site	Breadcrumb	Mean	Std. Dev.	N
Session_1	Cdn	M	168.012	112.466	10
		NM	131.146	67.857	10
		Total	149.579	92.359	20
	NCdn	M	180.237	90.642	10
		NM	144.491	101.141	10
		Total	162.364	95.255	20
	Total	M	174.124	99.612	20
		NM	137.819	84.104	20
		Total	155.972	92.834	40
Session_2	Cdn	M	110.666	36.362	10
		NM	137.416	103.260	10
		Total	124.041	76.585	20
	NCdn	M	118.652	56.582	10
		NM	171.780	124.098	10
		Total	145.216	97.745	20
	Total	M	114.659	46.472	20
		NM	154.598	112.500	20
		Total	134.629	87.333	40
Total	Cdn	M	139.339	86.505	20
		NM	134.281	85.101	20
		Total	136.810	84.737	40
	NCdn	M	149.445	80.040	20
		NM	158.136	111.069	20
		Total	153.790	95.658	40
	Total	M	144.392	82.419	40
		NM	146.208	98.408	40
		Total	145.300	90.195	80

Table 9: Tests of Between-Subjects Effects Speed

Dependent Variable: Time

Source	Type III Sum of Squares		df	Mean Square	F	Signif.	
Corrected Model	46103.626	(a)	7	6586.232	.795	.594	
Intercept	1688967.781		1	1688967.781	203.842	.000	
SS	9110.430		1	9110.430	1.100	.298	
SITE	5766.442		1	5766.442	.696	.407	
BT	65.979		1	65.979	.008	.929	
SS × SITE	351.919		1	351.919	.042	.837	
SS × BT	29066.195	(b)	1	29066.195	3.508	.065	*
SITE × BT	945.203		1	945.203	.114	.737	
SS × SITE × BT	797.458		1	797.458	.096	.757	
Error	596567.678		72	8285.662		.594	
Total	2331639.084		80			.000	
Corrected Total	642671.303		79			.298	

a) R-squared = .072 (Adjusted R-squared = -.019)
b) R-squared = .014 (Adjusted R-squared = -.011)

Table 10: Tests of Between-Subjects Effects Speed in Session One

Dependent Variable: Time

Source	Type III Sum of Squares	df	Mean Square	F	Signif.
Corrected Model	14819.032 (a)	3	4939.677	.553	.649
Intercept	973084.352	1	973084.352	109.033	.000
SITE	1634.639	1	1634.639	.183	.671
BT	13181.256 (b)	1	13181.256	1.477	.232
SITE × BT	3.137	1	3.137	.000	.985
Error	321288.230	36	8924.673		
Total	1309191.615	40			
Corrected Total	336107.262	39			

a) R-squared = .044 (Adjusted R-squared = -.036)
b) R-squared = .039 (Adjusted R-squared = -.014)

Table 11: Tests of Between-Subjects Effects Speed in Session Two

Dependent Variable: Time

Source	Type III Sum of Squares	df	Mean Square	F	Signif.
Corrected Model	22174.163 (a)	3	7391.388	.967	.419
Intercept	724993.859	1	724993.859	94.812	.000
SITE	4483.722	1	4483.722	.586	.449
BT	15950.918 (b)	1	15950.918	2.086	.157
SITE × BT	1739.524	1	1739.524	.227	.636
Error	275279.448	36	7646.651		
Total	1022447.470	40			
Corrected Total	297453.611	39			

a) R-squared = .075 (Adjusted R-squared = -.003)
b) R-squared = .054 (Adjusted R-squared = -.029)

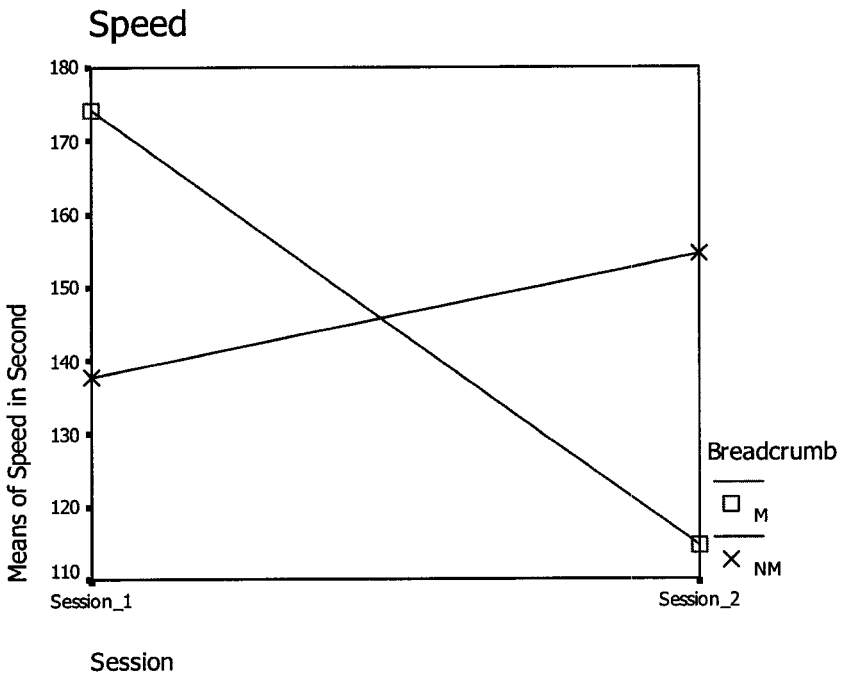

Figure 10: Speed ($SS \times BT$)

6.4 Frequency of Breadcrumb Clicks

Table 12 shows the descriptive statistics for frequency of breadcrumb clicks for all treatments in the experiment. Table 13 gives the main UANOVA table. A significant *2*-way interaction effect was observed between breadcrumb type and session ($F\ (1, 72) = 5.378, p = 0.023, r^2 = 0.008$) (see Table 13 and Figure 11). The value ($p < 0.05$) indicated that the frequency of using breadcrumbs were significantly different due to navigating with different breadcrumb techniques in different sessions.

Exploring this interaction effect further, a significant effect of using different breadcrumb techniques ($F\ (1, 36) = 5.470, p = 0.025, r^2 = 0.127$) was found in the first session. No significant effect was found in the second session. Table 14 shows the results of session one, Table 15 the results of session two. In the first session, the mean frequency of using breadcrumbs was -0.024 for subjects navigating with menu breadcrumb, which indicated very low breadcrumb usage, whereas the mean frequency of using breadcrumbs was 0.172 for subjects navigating with non-menu breadcrumbs, which showed more frequency of breadcrumb clicks (see Table 12 and Figure 12).

Table 12: Descriptive Statistics Frequency

Dependent Variable: Frequency of BC Clicks

Session	Site	Breadcrumb	Mean	Std. Dev.	N
Session_1	Cdn	M	.040	.226	10
		NM	.137	.225	10
		Total	.088	.225	20
	NCdn	M	-.089	.327	10
		NM	.207	.269	10
		Total	.059	.329	20
	Total	M	-.024	.282	20
		NM	.172	.244	20
		Total	.074	.278	40
Session_2	Cdn	M	.105	.308	10
		NM	-.045	.309	10
		Total	.030	.310	20
	NCdn	M	.127	.266	10
		NM	.084	.307	10
		Total	.106	.280	20
	Total	M	.116	.281	20
		NM	.019	.307	20
		Total	.068	.294	40
Total	Cdn	M	.072	.265	20
		NM	.046	.279	20
		Total	.059	.269	40
	NCdn	M	.019	.311	20
		NM	.145	.288	20
		Total	.082	.302	40
	Total	M	.046	.286	40
		NM	.096	.284	40
		Total	.071	.285	80

Table 13: Tests of Between-Subjects Effects Frequency

Dependent Variable: Frequency of BC Clicks

Source	Type III Sum of Squares		df	Mean Square	F	Signif.	
Corrected Model	.672	(a)	7	.096	1.206	.311	
Intercept	.399		1	.399	5.021	.028	
SS	.001		1	.001	.009	.924	
SITE	.011		1	.011	.136	.713	
BT	.050		1	.050	.624	.432	
SS × SITE	.055		1	.055	.695	.407	
SS × BT	.428	(b)	1	.428	5.378	.023	**
SITE × BT	.117		1	.117	1.466	.230	
SS × SITE × BT	.011		1	.011	.133	.716	
Error	5.729		72	.080			
Total	6.800		80				
Corrected Total	6.400		79				

a) R-squared = .105 (Adjusted R-squared = .018)
b) R-squared = .008 (Adjusted R-squared = -.018)

Table 14: Tests of Between-Subjects Effects Frequency in Session One

Dependent Variable: Frequency of BC Clicks

Source	Type III Sum of Squares	df	Mean Square	F	Signif.
Corrected Model	.492 (a)	3	.164	2.332	.090
Intercept	.217	1	.217	3.090	.087
SITE	.009	1	.009	.122	.729
BT	.385 (b)	1	.385	5.470	.025 **
SITE × BT	.099	1	.099	1.405	.244
Error	2.531	36	.070		
Total	3.240	40			
Corrected Total	3.023	39			

a) R-squared = .163 (Adjusted R-squared = .093)
b) R-squared = .127 (Adjusted R-squared = .104)

Table 15: Tests of Between-Subjects Effects Frequency in Session Two

Dependent Variable: Frequency of BC Clicks

Source	Type III Sum of Squares	df	Mean Square	F	Signif.
Corrected Model	.179 (a)	3	.060	.672	.575
Intercept	.183	1	.183	2.059	.160
SITE	.058	1	.058	.648	.426
BT	.093 (b)	1	.093	1.047	.313
SITE × BT	.028	1	.028	.320	.575
Error	3.198	36	.089		
Total	3.560	40			
Corrected Total	3.377	39			

a) R-squared = .053 (Adjusted R-squared = -.026)
b) R-squared = .028 (Adjusted R-squared = .002)

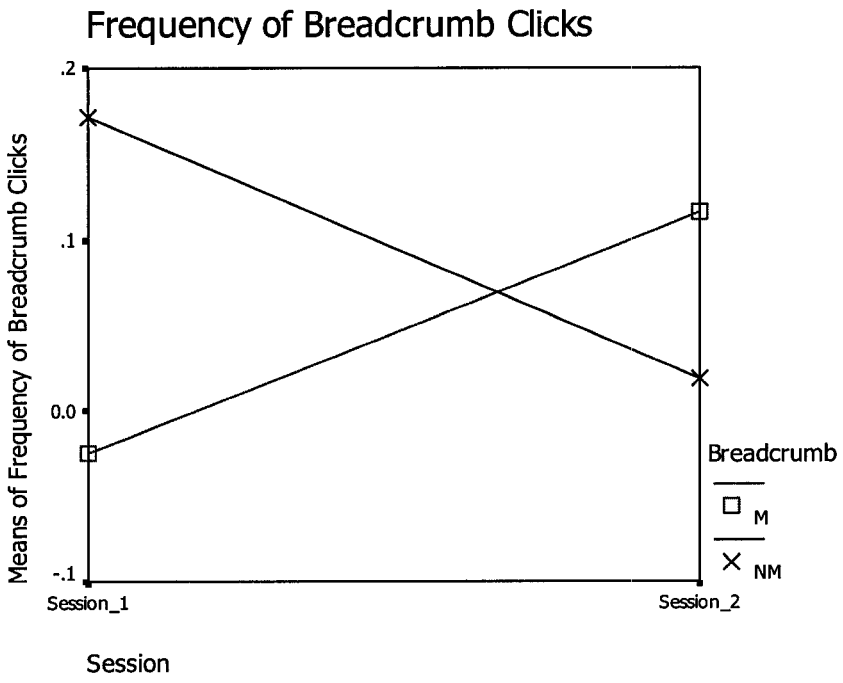

Figure 11: Frequency of Breadcrumb Clicks ($SS \times BT$)

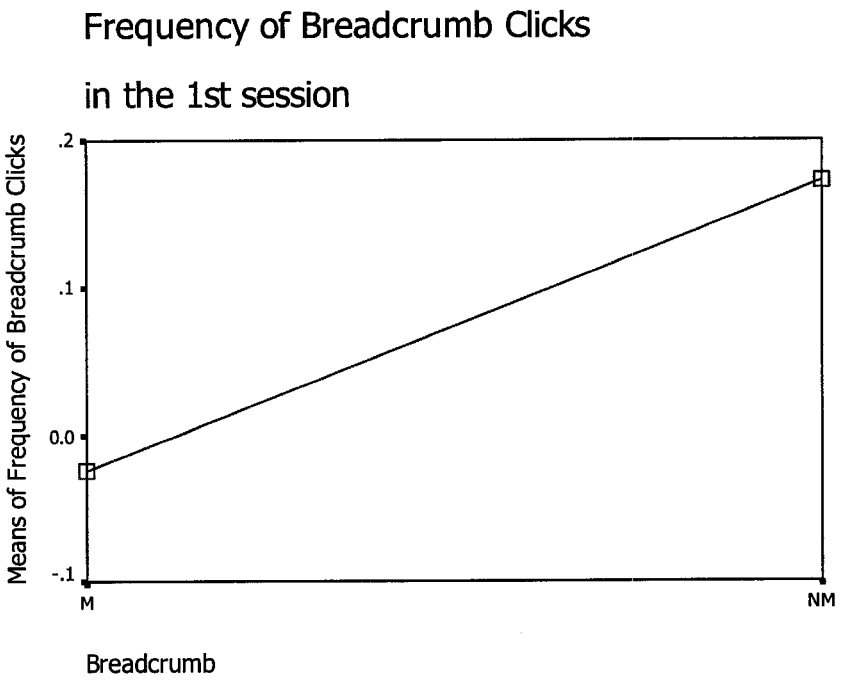

Figure 12: Frequency of Breadcrumb Clicks (*SS1, M vs. NM*)

6.5 P.A. Smith's Lostness

Table 16 presents the descriptive statistics of P.A. Smith's lostness for all treatments in the experiment. Table 17 is the main UANOVA table. First, the corrected model was significant ($p = 0\ .035$). This meant that some of the factors were significant enough to carry the other factors in the model. Second, there was a significant effect ($F\ (1,\ 72) = 8.966, p = 0.004, r^2 = 0.102$) of site. The value ($p < 0.05$) indicated that subjects' lostness differed significantly between navigating different sites (see Figure 13). The results for session ($F\ (1,\ 72) = 2.763, p = 0.101, r^2 = 0.031$) showed marginal support that session might also have affected subjects' lostness (see Figure 14). The results for $SS \times ST \times BT$ ($F\ (1,\ 72) = 2.724, p = 0.103, r^2 = 0.147$) also suggested a marginally significant 3-way interaction effect of breadcrumb types, sites and sessions. The effect size was the sum effect of breadcrumb types, sites, and sessions. This indicates that subjects navigating with different breadcrumb types using different sites in different sessions might have achieved different performance of lostness (see Figure 15).

As subjects' lostness performance data were compared based on each session, we found no effect for using different breadcrumb techniques in either session, ($F\ (1,\ 36) = 0.915, p = 0.345, r^2 = 0.020$) in session one, ($F\ (1,\ 36) = 0.407, p = 0.528, r^2 = 0.102$) in session two. A significant site effect ($F\ (1,\ 36) = 7.597, p = 0.009, r^2 = 0.166$), however was found in session one. No significant difference was found in session two. In the first session, subjects navigating the Canadian site ($L = 0.672$) were significantly less lost than subjects navigating the non-Canadian site ($L = 0.813$) (see Table 16 and Figure 16). Table

18 shows the results of session one, Table 19 the results of session two. The finding indicates that sites have played a significant role in the first session, but not in the second.

Table 16: Descriptive Statistics Lostness

Dependent Variable: Lostness

Session	Site	Breadcrumb	Mean	Std. Dev.	N
Session_1	Cdn	M	.618	.166	10
		NM	.725	.233	10
		Total	.672	.205	20
	NCdn	M	.817	.065	10
		NM	.809	.139	10
		Total	.813	.106	20
	Total	M	.718	.160	20
		NM	.767	.192	20
		Total	.742	.176	40
Session_2	Cdn	M	.650	.117	10
		NM	.617	.135	10
		Total	.634	.124	20
	NCdn	M	.670	.194	10
		NM	.776	.251	10
		Total	.723	.225	20
	Total	M	.660	.156	20
		NM	.697	.212	20
		Total	.678	.185	40
Total	Cdn	M	.634	.141	20
		NM	.671	.193	20
		Total	.653	.168	40
	NCdn	M	.744	.160	20
		NM	.793	.198	20
		Total	.768	.179	40
	Total	M	.689	.159	40
		NM	.732	.203	40
		Total	.710	.182	80

Table 17: Tests of Between-Subjects Effects Lostness

Dependent Variable: Lostness

Source	Type III Sum of Squares		df	Mean Square	F	Signif.	
Corrected Model	.482	(a)	7	.069	2.314	.035	
Intercept	40.358		1	40.358	1355.654	.000	
SS	.082	(b)	1	.082	2.763	.101	*
SITE	.267	(c)	1	.267	8.966	.004	**
BT	.037		1	.037	1.238	.270	
SS × SITE	.014		1	.014	.459	.500	
SS × BT	.001		1	.001	.026	.872	
SITE × BT	.001		1	.001	.024	.876	
SS × SITE × BT	.081	(d)	1	.081	2.724	.103	*
Error	2.143		72	.030			
Total	42.984		80				
Corrected Total	2.626		79				

a) R-squared = .184 (Adjusted R-squared = .104)
b) R-squared = .031 (Adjusted R-squared = .019)
c) R-squared = .102 (Adjusted R-squared = .091)
d) R-squared = .147 (Adjusted R-squared = .113)

Table 18: Tests of Between-Subjects Effects Lostness in Session One

Dependent Variable: Lostness

Source	Type III Sum of Squares		df	Mean Square	F	Signif.	
Corrected Model	.258	(a)	3	.086	3.257	.033	
Intercept	22.042		1	22.042	834.572	.000	
SITE	.201	(b)	1	.201	7.597	.009	**
BT	.024	(c)	1	.024	.915	.345	
SITE × BT	.033		1	.033	1.258	.269	
Error	.951		36	.026			
Total	23.251		40				
Corrected Total	1.209		39				

a) R-squared = .213 (Adjusted R-squared = .148)
b) R-squared = .166 (Adjusted R-squared = .144)
c) R-squared = .020 (Adjusted R-squared = -.006)

Table 19: Tests of Between-Subjects Effects Lostness in Session Two

Dependent Variable: Lostness

Source	Type III Sum of Squares		df	Mean Square	F	Signif.
Corrected Model	.142	(a)	3	.047	1.428	.250
Intercept	18.398		1	18.398	555.350	.000
SITE	.080		1	.080	2.412	.129
BT	.013	(b)	1	.013	.407	.528
SITE × BT	.049		1	.049	1.466	.234
Error	1.193		36	.033		
Total	19.733		40			
Corrected Total	1.335		39			

a) R-squared = .106 (Adjusted R-squared = .032)
b) R-squared = .010 (Adjusted R-squared = -.016)

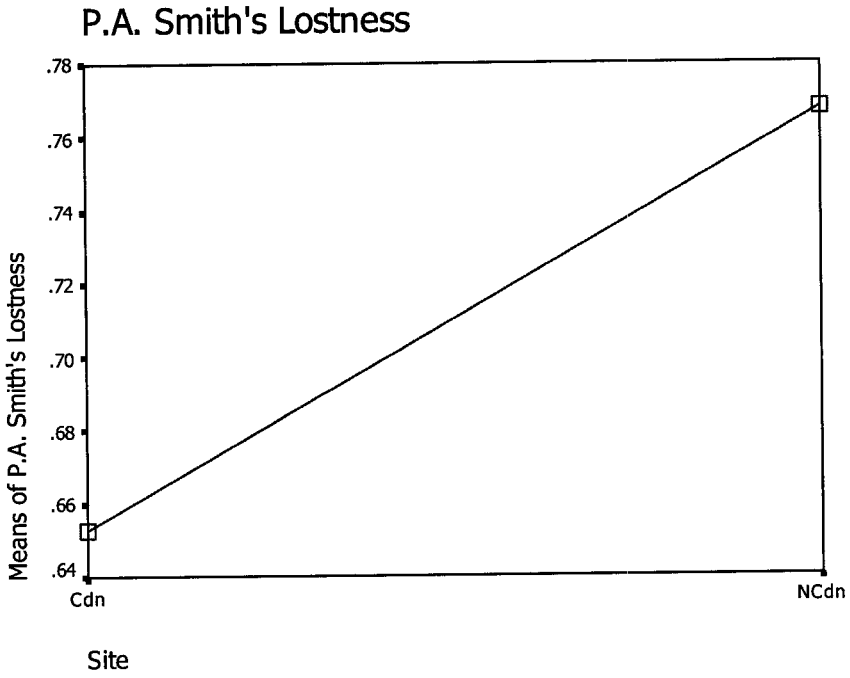

Figure 13: P.A. Smith's Lostness (*C* vs. *NC*)

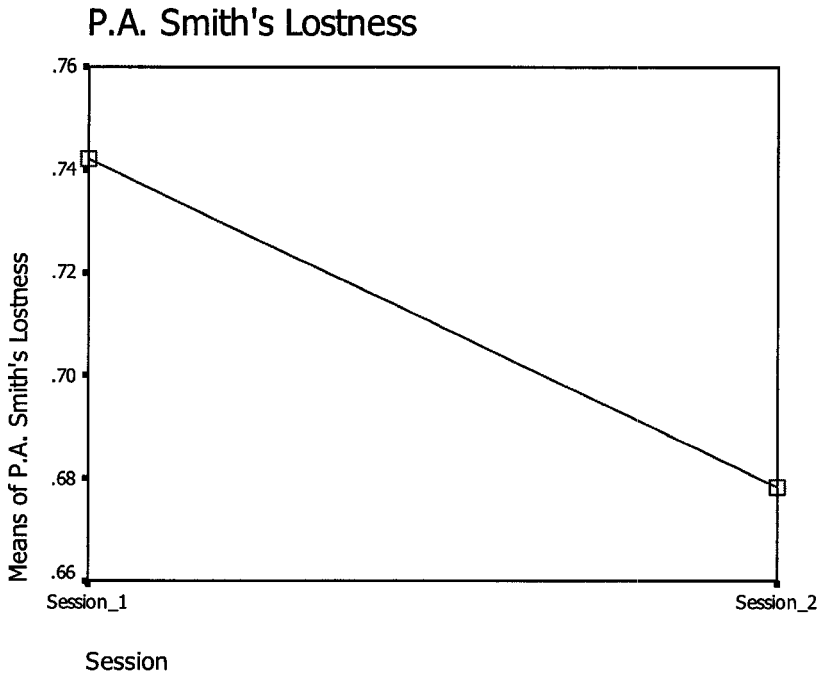

Figure 14: P.A. Smith's Lostness (*SS1* vs. *SS2*)

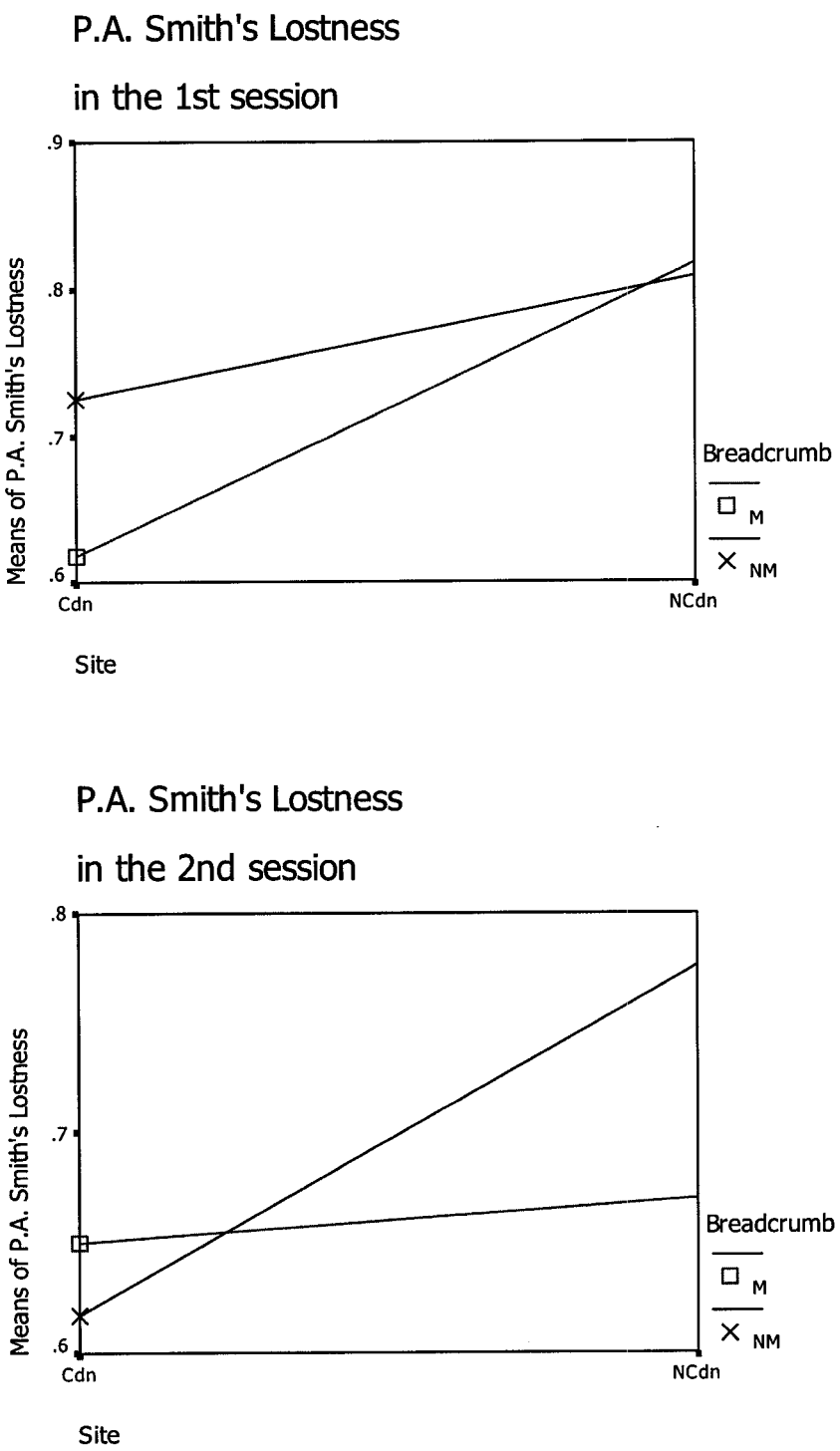

Figure 15: P.A. Smith's Lostness ($SS \times ST \times BT$)

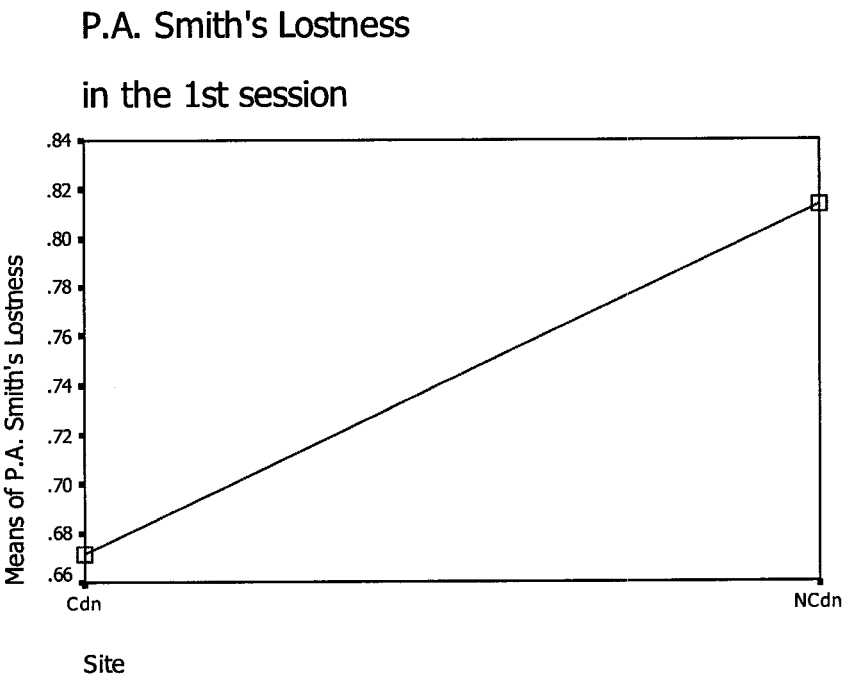

Figure 16: P.A. Smith's Lostness (*SS1, C vs. NC*)

6.6 Satisfaction

Table 20 shows the descriptive statistics of subjects' satisfaction for using different breadcrumb techniques. Table 21 is the main UANOVA table. A marginally significant effect was observed for session (F (*1*, *72*) = *2.724*, p = *0.103*, r^2 = *0.034*). The value suggested that subjects might get small different satisfaction for using breadcrumb techniques between session one and session two (see Table 20 and Figure 17).

Table 20: Descriptive Statistics Satisfaction

Dependent Variable: Survey of Satisfaction

Session	Site	Breadcrumb	Mean	Std. Dev.	N
Session_1	Cdn	M	3.644	.590	9
		NM	3.770	.383	10
		Total	3.711	.482	19
	NCdn	M	3.278	.533	9
		NM	3.790	.461	10
		Total	3.547	.549	19
	Total	M	3.461	.577	18
		NM	3.780	.412	20
		Total	3.629	.516	38
Session_2	Cdn	M	3.920	.569	10
		NM	3.800	.787	10
		Total	3.860	.672	20
	NCdn	M	3.880	.860	10
		NM	3.811	.590	9
		Total	3.847	.725	19
	Total	M	3.900	.710	20
		NM	3.805	.682	19
		Total	3.854	.689	39
Total	Cdn	M	3.789	.580	19
		NM	3.785	.603	20
		Total	3.787	.584	39
	NCdn	M	3.595	.769	19
		NM	3.800	.511	19
		Total	3.697	.652	38
	Total	M	3.692	.679	38
		NM	3.792	.553	39
		Total	3.743	.616	77

Table 21: Tests of Between-Subjects Effects Satisfaction

Dependent Variable: Survey of Satisfaction

Source	Type IV Sum of Squares		df	Mean Square	F	Signif.	
Corrected Model	2.640	(a)	7	.377	.992	.444	
Intercept	1072.334		1	1072.334	2820.998	.000	
SS	1.035	(b)	1	1.035	2.724	.103	*
SITE	.169		1	.169	.445	.507	
BT	.242		1	.242	.636	.428	
SS × SITE	.121		1	.121	.319	.574	
SS × BT	.820		1	.820	2.157	.146	
SITE × BT	.230		1	.230	.605	.439	
SS × SITE × BT	.135		1	.135	.355	.553	
Error	26.229		69	.380			
Total	1107.560		77				
Corrected Total	28.869		76				

a) R-squared = .091 (Adjusted R-squared = -.001)
b) R-squared = .034 (Adjusted R-squared = .021)

Figure 17: Satisfaction (*SS1* vs. *SS2*)

6.7 Summary of Results

6.7.1 MANOVA

When all dependent variables were considered as a whole, *SS* ($p = 0.105$) and *SS* × *BT* ($p = 0.107$) provided marginal support that subjects' performance might differ. When subjects' performance data were analyzed based on each session, navigating with different breadcrumb techniques produced significant variances only in the first session ($p = 0.049$).

6.7.2 Speed

When the speed measure was tested, *SS* × *BT* ($F(1, 72) = 3.508, p = 0.065, r^2 = 0.014$) showed marginal significance with small effect size. When subjects' speed data were analyzed for each session, navigating with different breadcrumb techniques achieved comparable speeds for both sessions.

6.7.3 Frequency of Breadcrumb Clicks

When the frequency measure was examined, *SS* × *BT* ($F(1, 72) = 5.378, p = 0.023, r^2 = 0.008$) was significant. However, the effect size was quite small. When subjects'

frequency data of each session were analyzed, navigating with different breadcrumb techniques ($F\ (1, 36) = 5.470, p = 0.025, r^2 = 0.127$) produced significant variance with medium effect size in the first session. In our experiment, the frequency of using breadcrumbs for menu breadcrumb users (*Frequency* = *-0.024*) was significantly less than the frequency of using breadcrumbs for non-menu breadcrumb users (*Frequency* = *0.172*).

6.7.4 P.A. Smith's Lostness

When the lostness measure was concerned, *ST* ($F\ (1, 72) = 8.966, p = 0.004, r^2 = 0.102$) showed significance with medium effect size. *SS* ($F\ (1, 72) = 2.763, p = 0.101, r^2 = 0.031$) showed marginal significance with small effect size, $SS \times ST \times BT$ ($F\ (1, 72) = 2.724, p = 0.103, r^2 = 0.147$) was also marginally significant. The effect size was a sum effect of breadcrumbs, sites, and sessions. When subjects' lostness data were analyzed based on each session, no significant differences for using different breadcrumb techniques were found for either session. Navigating different site however produced significant variance with large effect size in the first session ($F\ (1, 36) = 7.597, p = 0.009, r^2 = 0.166$). Subjects navigating the Canadian site (*Lostness* = *0.672*) were significantly less lost than subjects navigating the non-Canadian site (*Lostness* = *0.813*).

6.7.5 Satisfaction

When satisfaction measure was investigated, *SS* (F (*1*, *72*) = *2.724*, p = *0.103*, r^2 = *0.034*) showed marginal significance with medium effect size.

Chapter 7 Discussion

Our goals in this study were to investigate whether navigating with menu breadcrumbs would be better than navigating with non-menu breadcrumbs based on speed, frequency, lostness, and satisfaction measures. We analyzed subjects' performance data for the experiment as a whole. Except for a significant site effect on the lostness measure, the results indicated that many of our dependent variables involved marginal session effects or marginal interaction effects of breadcrumb type and session. As the effect sizes gained from the experiment were small, the marginally significant results reported probably had little impact on subjects' performance. We also analyzed subjects' performance data based on each session. In the first session, subjects navigating the Canadian site were less lost than they were navigating the non-Canadian site. In addition, subjects navigating with menu breadcrumbs used breadcrumbs less frequently than navigating with non-menu breadcrumbs. Navigating with different breadcrumb techniques however, did not produce any significant variances for the speed, lostness, and satisfaction measure in either session. These findings are now discussed.

7.1 Speed

We found that subjects navigating with menu breadcrumbs performed similarly in terms of speed to subjects navigating with non-menu breadcrumbs in both sessions. The finding indicated that in addition to providing extra information about the site hierarchy,

navigating with menu breadcrumbs was comparable to non-menu breadcrumbs in terms of speed.

7.2 Frequency of Breadcrumb Clicks

In the first session, we found that subjects navigating with menu breadcrumbs less frequently used breadcrumbs than they were navigating with non-menu breadcrumbs. This may have been because menu breadcrumbs are a new technique, and users were unfamiliar with it and therefore were more comfortable navigating using the back button. In the second session, subjects navigating with different breadcrumb techniques however, achieved similar usage of breadcrumbs. This may have been because subjects became familiar with breadcrumbs in the first session and therefore were more comfortable to extend this concept to menu breadcrumbs. Another reason might be subjects' familiarity with our experimental setting. We expect to explore the issue in a future study.

7.3 P.A. Smith's Lostness

Regarding the lostness measure, subjects navigating with different breadcrumb techniques exhibited similar levels of lostness. However, we found a significant site effect particularly in the first session. Subjects navigating the Canadian site were significantly less lost than they were navigating the non-Canadian site, and especially in the first session. The reason might be related to the theoretical notation of "information

scent". According to Information Foraging Theory, information scent is the visual and linguistic cues that enable an information searcher to determine whether a source, particularly a website, has the information they seek, as well as to navigate to the desired data (Pirolli and Card, 1995). Subjects may have performed better using the Canadian site than the non-Canadian site, since the category labels of the Canadian site may have been more distinctive along the site hierarchy. When subjects' lostness performance data in the second session was examined, we found no site effect. The reason could be that in the second session subjects were more comfortable with our breadcrumb techniques or the experimental settings and overcame these initial difficulties.

We expect to perform more studies in this area to investigate if navigating with menu breadcrumbs will gain better lostness performance than navigating with non-menu breadcrumbs using a non-structured or deep-structured website after formal practice is provided.

7.4 Satisfaction

We found that subjects navigating with menu breadcrumbs gained a similar satisfaction as subjects navigating with non-menu breadcrumbs in both sessions. Our open-ended question concerning subjects' preference of different breadcrumb types in the satisfaction survey indicated some benefits and improvement of menu breadcrumb design. The typical benefits of using menu breadcrumbs are listed as follows:

- "The pull-down menu reduces the horizontal scrolling of things —— so I felt better to navigate through them."
- "Breadcrumbs with pulled-down menu would help us to navigate better since it is narrowing down the topic and helps to confine the search."
- "Breadcrumbs with pulled-down menu made it more easy because some times, I would take too much time searching for something and forget where I was and what I had and hadn't tried... the menu's made this aspect of searching better."
- "It helps users to figure out what content in the upper level."
- "Everything is clearly shown with the drop box without having going back to check the options."

Some difficulties with menu breadcrumbs were also noted:

- "The pulled down menu might need some time getting used to"
- "The breadcrumbs with the pull down menu got in the way when trying to navigate around the site if I did not mean for the pull down menus to appear."
- "I can not click the links of pulled-down menu directly, so it is not much helpful."

Chapter 8 Future Work

This work is an initial experiment in the use of menu breadcrumbs.

Session played a complicated role in our experimental design. In the second session, subjects navigating with menu breadcrumbs gained a similar performance on many of our measures as subjects navigating with non-menu breadcrumbs. We cannot tell whether the improvement was due to participants had learnt the usage of the technique from the first session or they were just more familiar with our experiment setting. Therefore, there is a need for future work to investigate the effect of session.

We also mentioned a significant site effect concerning lostness. As this was not anticipated in our experimental design, further work using non-structured or deep-structured websites should follow to investigate whether navigating with menu breadcrumbs would achieve better lostness performance than navigating with non-menu breadcrumbs.

Some innovative ideas concerning the menu breadcrumb design were gathered in our satisfaction survey. One subjects mentioned in the experiment that he could not click the links of pulled-down menu directly, so he felt the menu breadcrumbs were not much help. In future work, we expect to activate the links of the menu lists (the links of the menu list were not active in our experiment) to investigate the full usage of menu breadcrumbs. The benefit is that users could jump one-step further than when using non-menu

breadcrumbs by clicking the links inside the menu lists presented. Another subject mentioned that the breadcrumbs with the pull down menu got in the way when trying to navigate around the site if he did not mean for the pull down menus to appear. In the next study, we expect to create a small icon beside the menu breadcrumbs. When the icon is clicked, it will pop up the list of menu breadcrumbs. The benefit is to allow users to choose to navigate or not to navigate with menu breadcrumbs. Since most of the participants were undergraduate and graduate students with substantial experience of web browsing, it seemed that non-menu breadcrumbs were better understood than menu breadcrumbs in the first session. The menu breadcrumbs were new and complicated; one subject mentioned that he needed time to get familiar with the techniques, some leaning effects might have missed in our experiment. In the next study, formal training of menu breadcrumbs before running the experiment could be provided to investigate this effect.

In addition, other issues need further investigation. First, our subjects were limited to a small age group and a similar education background. We expect more subjects with different ages and educational backgrounds could be tested to determine whether our findings are generalizable. Second, the difficulty of task was hard to measure. Therefore, tasks may be better in random order to be performed by subjects. Concerning the last task, which required comparison of two webpages, the comparison would be better between webpages sharing non-root grandparent pages instead of parent pages to prevent subjects from reaching the other leaf page by accident. Third, the question of preference was designed only to include the choice of menu breadcrumbs and non-menu breadcrumbs.

The arbitrary question left no option for users if they were not satisfied with both or if other ideas might exist.

Finally, the analyses were done on a high level without accounting for task and subject differences. Detailed analyses on every task basis and subjects' background may help answer more questions about the benefits of menu breadcrumbs.

Chapter 9 Conclusion

Internet users can easily get lost and experience difficulty finding information online (Nielsen, 1998). Many navigation tools are therefore, developed to provide quick and easy access to information. One of them is breadcrumbs. In theory, the technique is ideal for navigating large sites as it provides information to users about the site structure, and gives a way for the users to select links from the breadcrumbs to go up in the site hierarchy. Some studies as reviewed earlier have found this tool to be useful. Breadcrumbs typically come in three forms: location breadcrumbs, path breadcrumbs, and attribute breadcrumbs. The current study concentrated on the location breadcrumbs in the context of people searching for information on the WWW. Unlike menus, breadcrumbs only show one path through the site hierarchy. We developed a novel extension of existing breadcrumbs —— menu breadcrumbs. In addition to providing a list of links about the position of the current webpage within the site hierarchy, the menu breadcrumbs provide pop-up menus of the sub-directories available from the webpages represented by the breadcrumbs. Menu breadcrumbs not only show where the current webpage resides within the site, the technique also offers users a local map of the neighborhood of each intersection along the location path. We compared menu breadcrumbs to non-menu breadcrumbs to determine whether menu breadcrumbs were better than non-menu breadcrumbs based on speed, frequency of usage, P.A. Smith's lostness, and subjects' satisfaction measures. Forty subjects participated in our information searching experiment by navigating with these two different breadcrumbs using two different websites in two sessions.

The results showed that subjects navigating the Canadian site were less lost than they were navigating the non-Canadian site. In addition, subjects navigating with menu breadcrumbs used fewer breadcrumbs than navigating with non-menu breadcrumbs in the first session. Navigating with different breadcrumb techniques however, did not produce any significant variances for the speed, lostness, or satisfaction measure in either session. On average in our experiment, other than providing extra information about the site hierarchy, performance with menu breadcrumbs is similar to performance with non-menu breadcrumbs. In future work, we expect to test a variety of users with formal training provided to investigate whether navigating with menu breadcrumbs will gain better overall performance than navigating with non-menu breadcrumbs using non-structured and deeply-structured websites.

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Appendix A: Consent Form

As deemed necessary by the Ethics Review Committee at Dalhousie University, the principal investigator provided research subjects with an informed consent form before the experiment started.

To let experiment groups be familiar to location breadcrumbs, an additional instruction sheet for using location breadcrumbs was provided as part of the consent form. This form gave participants the basic knowledge and skills to efficiently use breadcrumbs to locate online information. Participants of these groups read this form after they read the informed consent form.

We first presented the standard consent form followed by the supplementary instruction sheet for using breadcrumbs.

Breadcrumbs for Online Searching

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Introduction

We invite you to take part in a research study at Dalhousie University. You may participate in this study if you can use a graphical user interface (screen & mouse) to a web browser. This study is investigating how well people interact with location breadcrumbs (hyperlinks of the WWW). The information consent form tells you about what you will be asked to do, and any risks, inconvenience, or discomfort, which you might experience. If you have any concern and question about the study, please do not hesitate to ask the principal investigator Hui Teng or Dr. Blustein.

Procedure

You can participate two sessions of three types of information-seeking activities. These activities will be completed on a customized usability testing service known as Uzilla. We expect you to finish all these activities. However, you may withdraw your participation from the experiment at any time. The web pages you will use for the activities are adapted from the Government of Canada website. The use of the web pages for this experiment is allowed by the Government of Canada. The original web pages were made by Communication Canada. However, the web pages you will use in the experiment are not the official version of the web pages.

Activity 1: This activity will be to find out the path from home page to a page printed in the sheet marked "PAGE A" that you will read before starting this activity. Your task will be to navigate to "PAGE A" in the instrumental website. When you find the information, please click "complete" button in the Uzilla toolbar.

Activity 2: This activity will be to find out the path from "PAGE A" of activity one to another page printed in the sheet marked "PAGE B" that you will read before starting this activity. Your task will be to navigate to "PAGE B" in the instrumental website. When you find the information, please click "complete" button in the Uzilla toolbar.

Activity 3: This activity will consist of several short answer questions. Questions are both printed in the question card and shown on the screen. To answer these questions will require either studies of a single webpage or comparisons of two web pages. Your tasks will be to answer these questions by navigating to proper web pages. When you find the information, please click "complete" button in the Uzilla toolbar.

Both before the experiment and after you finish all of your assigned activities, you will be requested to fill in a questionnaire. The questionnaire will include questions such as your background, computer skills, satisfaction of using the website and difficulty to complete the tasks.

Risks and Benefits

No risks are anticipated in the present study. There are no compensation and direct benefits to your participation. However, the results of the study may contribute to WWW development.

Confidentiality

Your name and address will not be required when you answer the questions. Your data will be treated anonymously. Results of the study will be stored on a CD-ROM. The CD-ROM and the consent forms will be kept securely in Dr. Blustein's office. Only he has access to this information. After five-year period, the stored information will be erased (by destroying the CD-ROM).

Signature

By signing below, you agree to the following statement:

- I understand that I may withdraw my participation in this experiment at any time.
- I have read the procedure specified in the study.
- I have been given the opportunity to discuss it and my questions have been answered to my satisfaction.
- I have been informed that the research material will be held confidential.
- I also understand that in case of any complaint I might have about the experiment. I may contact:

  Patricia Lindley,
  Human Research Ethics/Integrity Coordinator,
  Office of Research Ethics, Dalhousie University,
  e-mail: patricia.lindley@dal.ca,
  Phone: (902)494-1462

- I hereby consent to take part in this study voluntarily.

_____	_____
Participant's Name	Participant's Signature
_____	_____
Researcher's Name	Researcher's Signature

Information sheet for Using Location Breadcrumbs

Breadcrumbs, in general are a list of hyperlinks separated by some characters and symbols. They are in the forms of location breadcrumbs, path breadcrumbs, attribute breadcrumbs, and have evolved as major navigator tools of WWW. In this experiment, only location breadcrumbs will be studied.

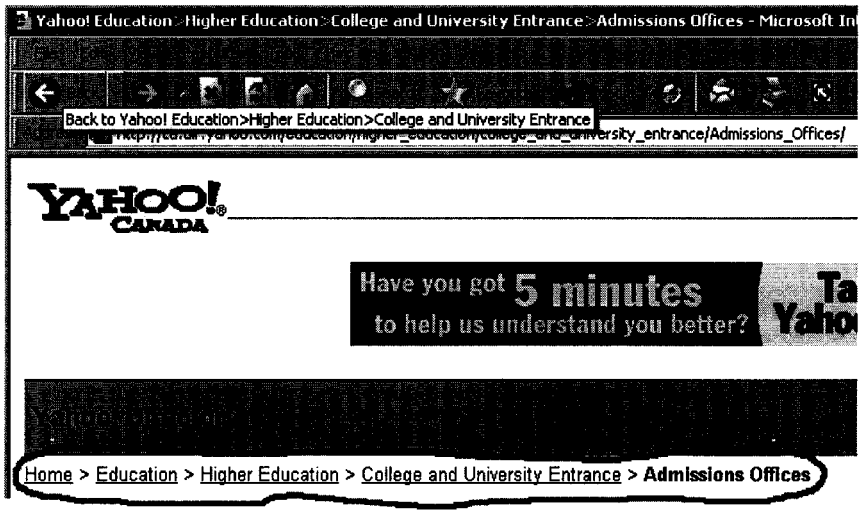
Location breadcrumbs convey the information about the position of a web page within the web site hierarchy. The technique provides users a way to select links from the breadcrumbs in order to go up in the site hierarchy. Location breadcrumbs are very common in the following presentation:

First Element > Second Element > Third Element > Last Element

The first element usually represents the site home page. The second element can be a sub directory of the first element, and the third element can be a sub directory of the second element. The last element usually represents the name of the current page.

Breadcrumbs usually go from left to right on the same line, and are placed near the top of the page, and below the browser navigational tools. The following is a real example taken from yahoo site[5] (Figure 1). The marked is the location breadcrumbs indicating the path from home page to the admission office of Canadian higher education.

Figure 1: An example of location breadcrumbs



Thanks for your participation to this experiment!

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[5] Source:
<URL:http://ca.dir.yahoo.com/education/higher_education/college_and_university_entrance/Admissions_Offices/>

Appendix B: Recruitment Instruments

The following notice was emailed to students of Dalhousie University and posted on poster boards around campus

Call for Study Participants

Hi, you are invited to participate in an experiment concerning human-computer interaction issues that arise in the use of breadcrumbs (hyperlinks) on the WWW.

The experiment will involve searching online information about governmental service for Canadian, and non-Canadian from Canadian Government Website. The experiment will be about one hour and will be scheduled at your convenience.

I am a master of Computer Science student. This study is part of my thesis and has been reviewed by the Social Sciences and Humanities Human Research Ethic Board of Dalhousie University. If you are interested, please send email to either hteng@cs.dal.ca or Jamie@cs.dal.ca. Thank you!

Appendix C: Questionnaires

The preliminary questionnaire was presented to the participants prior to the start of the experiment in order to measure their computer literacy and how knowledgeable they were of the information from governmental departments and agencies. The post-experimental questionnaire was presented to the participants at the end of the experiment asking participants to rate initial instruction, content of the website, accuracy, format, ease of use, ease of navigation, speed, satisfaction and so on, on a 4-point and 5-point Likert scale corresponding to the two different breadcrumb presentations.

Preliminary Questionnaire

1 Identification Number? _____ (required for identifying subject's input data)

2 Gender?
- Male
- Female
- Other _____

3 Age?
- <= 20
- 21 - 25
- 26 - 30
- 31 - 40
- 41 - 50
- > 50

4 Your highest education level?
- Undergraduate
- Master
- PhD
- Other _____

5 Are you a
- Student
- Faculty member
- Other _____

6 Of the following WWW browsers, check those that you have personally used and are familiar with?
- Internet Explorer
- Netscape
- Others _____

7 Please check your frequency of searching online information?
- At least once a day
- At least once a week
- At least once a month

8 For how many hours a week do you spend on the Internet?
- 10 hrs+
- 6 – 10 hrs
- 2 - 5 hrs
- Less than 1 hr

9 Which degrees are you studying for, or have completed? (check all that apply)
- Architecture
- Arts and Social Sciences
- Computer Science
- Dentistry
- Engineering
- Health Professions
- Law
- Business
- Medicine
- Science
- Others_____

10 Of the following, please check top 2 interests of your online surfing?
- Art
- Business
- E-mail
- Education
- Career
- Shopping
- Sport
- Travel
- Game & Entertainment
- Science & Technology
- Government & Law
- Health & Medicine
- News & Publishing
- Weather & Environment
- Social Sciences & Social Issues
- I'm an IT enthusiast
- Other _____

11. Have you ever used the Canadian Government website before?
- Yes
- No

12. How familiar are you with directories of websites (e.g. Yahoo, Google Directories)?

Familiar 1, 2, 3, 4, 5, Unfamiliar

13. Please estimate your frequency of using directories of websites (e.g. Yahoo, Google Directories)?
    - At least once a day
    - At least once a week
    - At least once a month

14. Do you expect the breadcrumbs to help you find things in the website?
Expect them to be very helpful 1, 2, 3, 4, 5, Do not expect them to help at all

Post-experimental Questionnaire

1. Questions will be asked only once after participants completing all activities

   a) Initial Instruction

   Was the guidance of the experiment clear and easy to follow?
   Difficult 1, 2, 3, 4, 5, Easy

   b) Preference

   All things considered, please check your preference of the following breadcrumb presentations?
   - Breadcrumbs with pulled-down menu
   - Breadcrumbs without pulled-down menu

   Please provide us your comment why did you make such a choice?

2. Question will be asked every time when participants completing every single session

   a) Breadcrumb Format

   Can you always see the breadcrumbs on the website?
   Never 1, 2, 3, 4, 5, Always

   Did breadcrumbs make the site easier to navigate?
   Disagree 1, 2, 3, 4, 5, Agree

   Did breadcrumbs help you complete the tasks with less difficulty?
   Disagree 1, 2, 3, 4, 5, Agree

   Did breadcrumbs direct you to the information you need faster?
   Disagree 1, 2, 3, 4, 5, Agree

   Were the breadcrumbs like what you expected to see?
   Different from what I expected, 1, 2, 3, 4, 5, Same as I expected

   How good or bad was this difference between what you expected and what you saw?
   Very bad 1, 2, 3, 4, 5, Very good

   All things considered, are you satisfied with the way in which the breadcrumbs are presented?
   Dissatisfied 1, 2, 3, 4, 5, Satisfied

b) Content of the Website

Does the website provide the precise information you needed to complete the tasks?
Never 1, 2, 3, 4, 5, Always

Was the content of this site well organized?
Not well organized, 1, 2, 3, 4, 5, Well organized

Was the content of the website clear and understandable?
Unclear 1, 2, 3, 4, 5, Clear

c) Ease of Use

Is your interaction with the system clear and understandable?
Unclear 1, 2, 3, 4, 5, Clear

d) Ease of Navigation

Are you able to easily move around within the site?
Difficult 1, 2, 3, 4, 5, Easy, N/A

e) Accuracy

Is the system error free?
No error free, 1, 2, 3, 4, 5, Error free

f) Speed

Are web pages downloaded efficiently?
Inefficiently, 1, 2, 3, 4, 5, Efficiently, N/A

g) Overall Satisfaction Rating

All things considered, please rate the overall satisfaction of this webpage format?
Poor, 1, 2, 3, 4, 5, Excellent

3. Question will be asked about each task specifically

a) Before task

Are you familiar with the content you will be looking for?
Very familiar, 1, 2, 3, 4, 5, Very unfamiliar

Please enter how long you expect finding Page A to take
< 2 minutes, 2 – 5 minutes, 6 – 10 minutes, > 10 minutes

b) After task

Please rank the difficulty to find the answer for the tasks you just completed.
Difficult 1, 2, 3, 4, 5, Easy, N/A

Appendix D: Tasks

The tasks presented to the participants involved a number of information seeking questions organized into two equivalent sets. Both sets of activities were completed by the participants with both webpage treatments. In one session, they completed the tasks using a webpage with one of the two treatments. In the other session, they completed equivalent tasks using a webpage with the other of the two treatments. Participants were randomly assigned to a block of sessions. Answers to these questions were in the form of the URL address of the webpage.

Session One

Q1)
Start from home page to find the path from the home page to *Page A-1*, and then the path from *Page A-1* to *Page B-1*.

PAGE A-1

New Home Energy Efficiency for Savings and Comfort

The energy efficiency of Canadian homes has improved greatly over the years. Thanks to major advances in building techniques and product innovation, today's new home owner can expect to use only half of the energy required for a similar home built in 1950, and at the same time enjoy a far more comfortable living environment.

Does this mean that as a new home buyer you need not be concerned with energy efficiency? No, far from it. While today's new homes offer an excellent starting point, there are still many opportunities, large and small, to increase the energy performance and comfort of your home.

Ask your professional new home builder for information and advice. The builder's specification list of materials and products is a great starting point. For instance, how will your home be insulated, and could you add extra insulation in the attic, the most exposed walls or the entire house? What are the cost implications and possible impact on construction? Your builder can explain these and other opportunities to help you make informed decisions to suit your budget and long-term plans.

PAGE B-1

Any representation which deceives a consumer with respect to the composition of a product may be a violation of this section.

Included Substances

- *A prepackaged product should not claim that it contains a substance when in fact it does not. For example, if the label on a product claims that it "contains lemon" when it contains no lemon, then the label may be found to be misleading.*

Excluded Substances

- *A prepackaged product may not claim that it does not contain a substance when it actually does. This same product label may also claim that it contains "no irritants". If it can be shown that the product contains a known irritant, then the label may be found to be misleading.*

Q2)

In Workers, find information about the current and forthcoming minimum hourly wage rate for experienced adult workers? The web page containing the answer is indicated as "the current and forthcoming minimum hourly wage rate for experienced adult workers".

Q3)
Find information about "six-month grace period" to repay student loan? The web page containing the answer is indicated as "Answer to the Question of 'what is the 'six-month grace period' to repay your student loan' ".

Q4)
Jane would like to fly to attend a conference in Toronto. She has 2 personal items that she doesn't know if she can bring with her on board, and which item might be dangerous for air traveling. For this question, answers will be from two web pages. The web pages containing the answer are indicated as "Answers to the Question of 'which items are permitted or not permitted on board for air traveling' ".

Session Two

Q1)
Start from home page to find the path from the home page to *Page A-2*, and then the path from *Page A-2* to *Page B-2*.

PAGE A-2

Acadians of Nova Scotia

In 1542, Italian explorer Verazzano named part of the eastern coast of North America Arcadia, after the pastoral region of Ancient Greece immortalized in Greek poetry. That coastal region is what is now Nova Scotia, New Brunswick, Quebec and part of Maine. Over the years, the name changed to Acadia.

In the 17th century, there were a hundred French families in Acadia. The Acadians had a strong sense of community and gradually developed their own culture. They stayed out of disputes between the French and the British and developed friendly relations with the Aboriginal peoples, learning their hunting and fishing techniques.

In the early 18th century, the British government, doubting the neutrality of the Acadians, demanded that they swear allegiance to the British Crown. The issue would cause discord for decades to come. In 1755, British Governor Charles Lawrence decided to settle the matter once and for all by deporting the Acadians from Nova Scotia and dispersing them among the 13 English colonies, from Massachusetts to Georgia.

In 1764, the Acadians were granted permission to return to Nova Scotia; however, they were prohibited from settling in any one area in numbers great enough to form a self-sufficient society. The Acadians therefore spread out along the Nova Scotia coast and remain scattered across Nova Scotia to this day. The greatest concentrations of Acadians are in the following regions: Argyle, Chéticamp, Clare, Annapolis Valley, Halifax-Dartmouth, Pomquet, Richmond and Sydney.

PAGE B-2

Aboriginal Peoples' Program supports an Aboriginal infrastructure at national, regional and community levels, for Indian, Métis and Inuit people who are not resident on reserves in Canada, to facilitate their participation in resolving issues that affect the quality of their lives through the following programs:

- *Aboriginal Representative Organizations Program*
- *Aboriginal Friendship Centre Program (AFCP)*
- *Aboriginal Languages Initiative*
- *Aboriginal Women's Program (AWP)*
- *Northern Native Broadcast Access Program (NNBAP)*

- *Canada-Northwest Territories Co-operation Agreement for French and Aboriginal Languages*
- *Canada-Yukon Cooperation and Funding Agreement on the Development and Enhancement of Aboriginal Languages*
- *Urban Multipurpose Aboriginal Youth Centre (UMAYC)*

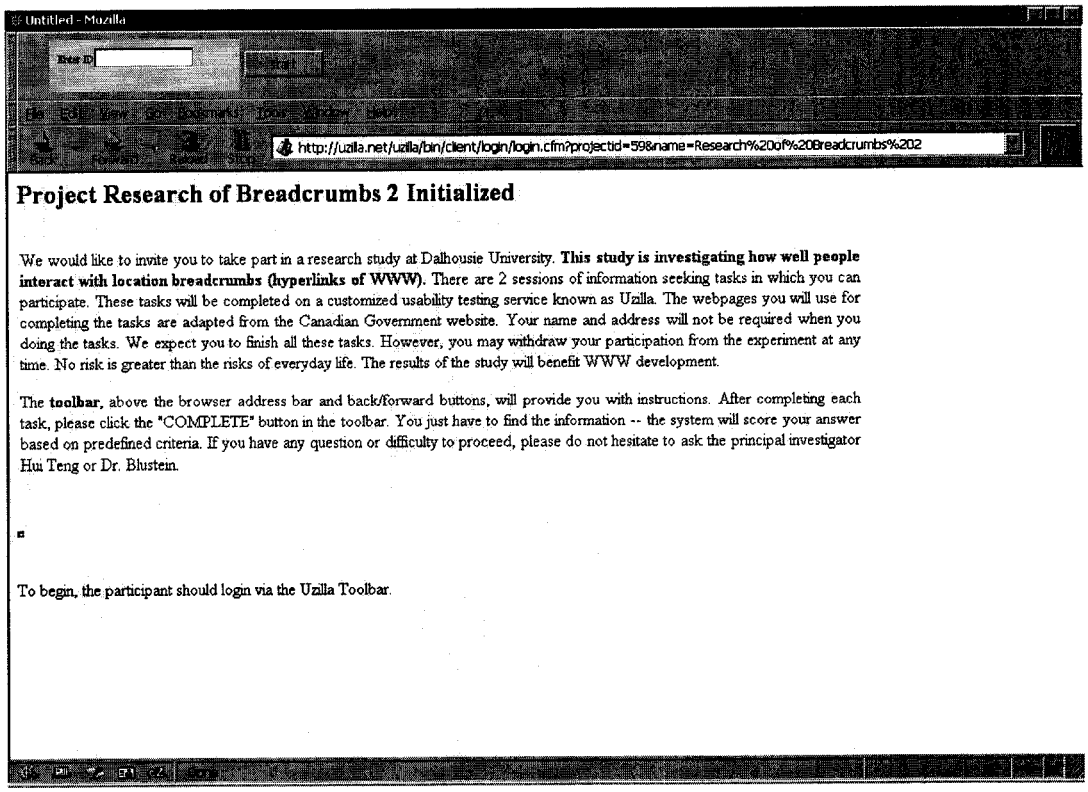
Q2)
In Environment and Sustainable Development, find information about what to do to conserve energy? The webpage containing the answer is indicated as "Answer to the question of conserving energy".

Q3)
Find information about choosing a partnership business? The webpage containing the answer is indicated as "Answer to the Question of 'choosing a partnership business' ".

Q4)
Peter has $300,000 Canadian dollars in his bank account. He is considering immigrating Canada. However he doesn't know if this amount money meets the requirement for Immigration of Skill Worker Class or Investor of Business Class. For this question, answers will be from two web pages. The web pages containing the answer are indicated as "Answer to the Question of 'if 300,000 CDN meets the requirement for Immigration of Skill Worker Class or Investor of Business Class' ".

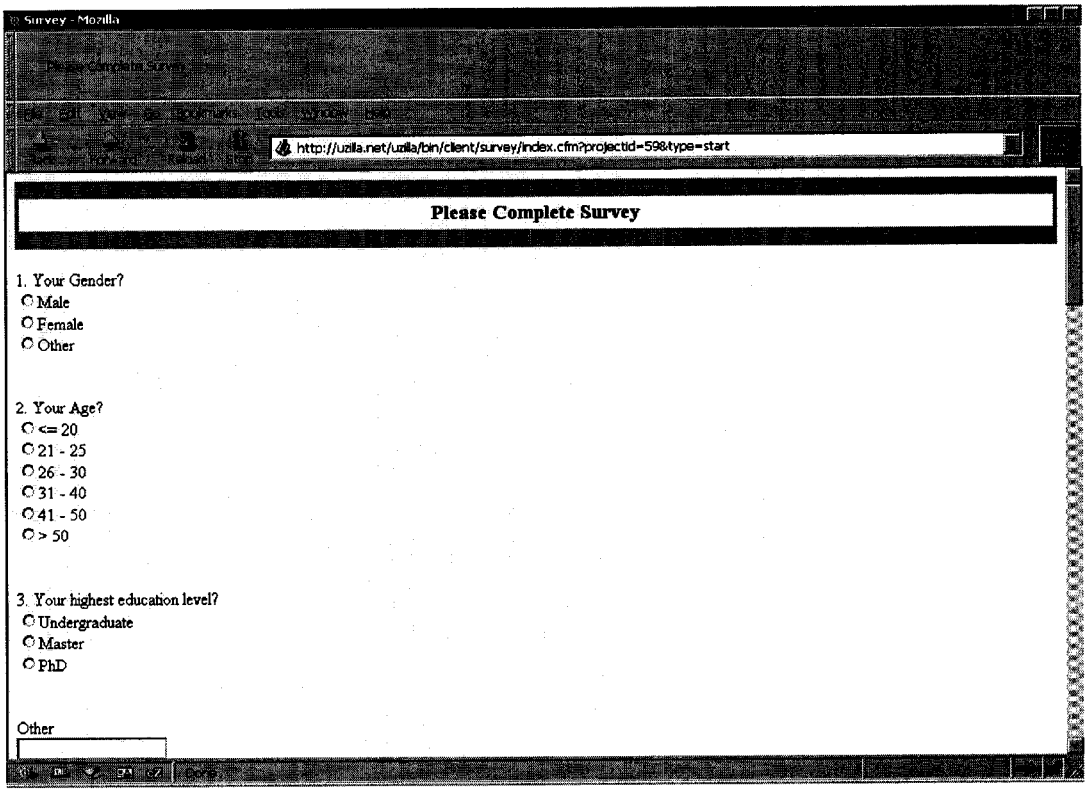
Appendix E: Experimental Environment

1. Begin the Experiment



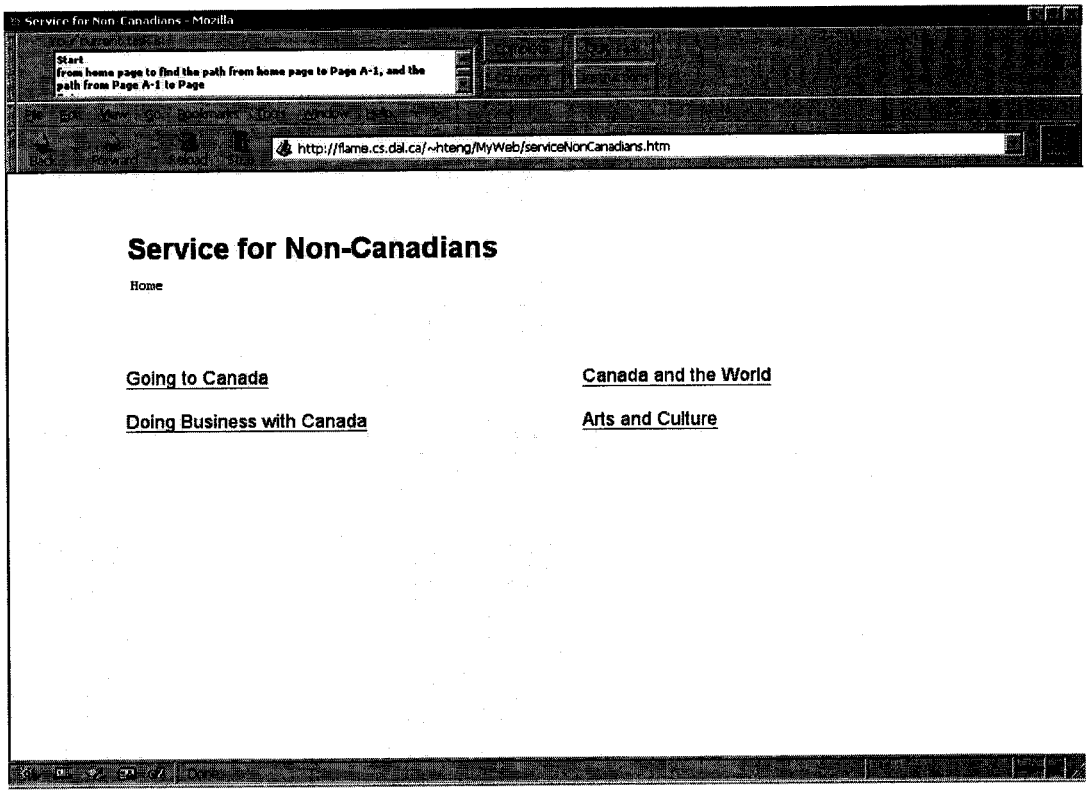
The snapshot shows the brief introduction to the experiment. Users need enter IDs to identify their input data to start the experiment.

2. Survey Section



The snapshot shows the preliminary questionnaire.

3. Activity Section



The snapshot shows the environment for working on the experiment activities. Four buttons were given for use in the top row of the Uzilla browser.

Complete: to confirm a completed task

Quit: to quit the current task

Instruction: to see the task instruction

Comment: to leave comment

Appendix F: Ethics Approval

Dalhousie University

OFFICE OF RESEARCH ETHICS ADMINISTRATION
Office of Research Services
321 Henry Hicks Academic Administration Building
Halifax, Nova Scotia
Canada B3H 4H6

Social Sciences and Humanities Research Ethics Board
Letter of Approval

Date: June 10,2003.

To: Hui Teng , Computer Science
James Blustein , Computer Science

The Dalhousie Social Sciences and Humanities Research Ethics Board has examined the following application for research involving human subjects:

Project # 2003-701

Title: Breadcrumbs for Online Searching

Submitted by: Hui Teng , Computer Science

and found the proposed research involving human subjects to be in accordance with Dalhousie Guidelines and the Tricouncil Policy Statement on *Ethical Conduct in Research Using Human Subjects.* This approval will be in effect for 12 months from the date indicated below.

Dalhousie Guidelines require that, on the anniversary of the effective date you must submit an annual report. Also, should there be any significant changes to either the research methodology, or the consent form used during the approval period, these changes must be submitted for ethics review. You must also notify the Office of Human Research Ethics and Integrity when the project is completed or terminated.

This letter is the official record of ethics approval by the Dalhousie Social Sciences and Humanities Research Ethics Board. You may use this letter to notify funding agencies that your project has undergone a thorough review and has been granted ethics approval.

Effective Date: June 9,2003. signed:

Copy sent to:
☑ Graduate Studies ☑ Research Services
Funding agency - N/A Award