

Assessing Usability through Perceptions of Information Scent

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Abstract

Information scent is an established concept for assessing how users interact with information retrieval systems. This paper proposes two ways of measuring user perceptions of information scent in order to assess the product quality of Web or Internet information retrieval systems. An empirical study is presented which validates these measures through an evaluation based on a live e-commerce application. This study shows a strong correlation between the measures of perceived scent and system usability. Finally the wider applicability of these methods is discussed.

1. Introduction

In this paper we present a factor that will contribute to the measurement of system usability. In particular we concentrate on the usability of Internet information retrieval systems (IIS)¹. This factor is based on the concept of 'information scent' as encapsulated by the structure of an IIS. We discuss the validity of our approach and present an empirical study where we collect information scent data from 30 users of an e-commerce website.

Our results suggest that the usability of a system should be judged by the ability of users to explore and navigate through the system, rather than more traditional measures such as task completion rates or task completion time. Our results will be useful to current system designers and those developing tools to assist in the design and implementation of IIS.

We discuss the context of information scent in section 2 and show how it relates to usability. In section 3 we describe the information scent data we collected in our empirical study. We present the results

¹ IISs include e-commerce web sites, information portals and corporate intranets.

of our empirical study in section 4 and discuss these results in section 5. We summarise and conclude in section 6.

2. Background

Usability is a key factor in systems development and use as reflected in its inclusion in many software quality models. For example the ISO 9126 standard [1] on software quality (derived from McCall's FCM model [2]) identifies usability as one of the six key factors contributing to product quality. It decomposes usability into a set of attributes model the "capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions."

Usability is particularly important for IIS where there are many competing sources of information and products. In this environment less usable systems will *not* be used. Assessing the usability of IIS is therefore critically important at the analysis, design and testing stages of development.

2.1 Metrics for IIS Usability

Many different criteria and metrics have been proposed for assessing system usability in general and the usability of IIS in particular [3]. These include:

- structural metrics based on site topology such as site breadth and depth [4] [5]
- performance metrics such as download times [6], task completion rates and overall elapsed times [7]
- design metrics based on the placement of screen items, aesthetic appeal and ability to capture users' attention [8]

These metrics are generally, by their nature, limited to specific aspects of usability, which can be related to individual factors in traditional models of information retrieval. However, as a group they do not provide a framework that captures the complex interaction of

influences that determine user behaviour and ultimately define usability.

Information scent is a concept derived from information foraging theory [9] that can provide a unified framework to explain user behaviour. Scent has been defined as “the value of information gained per unit cost of processing the source” [9]. This clearly links information scent to FCM usability criteria such as *communicability* and *efficiency* and ISO capabilities of *understandability*, *learnability* and *operability*. Systems with higher levels of scent offer higher information gain (and therefore communicability) and lower cost (high efficiency) suggesting that such systems will be more usable.

Information scent is a relative concept that depends upon the task being undertaken by a particular user. In previous work, scent has variously been measured by expert judgments [10] or as an amalgamated relevance score based on the match between a task (as represented by a number of search terms) and individual pages [11]. Our study uses a five-point scale of *perceived scent* as a measure of information scent that users actually receive. This is in contrast to expert assessments of how much available scent is provided by the system, i.e. is available to be received.

2.2 Information Scent and Usability

Our approach to assessing usability via information scent takes into account features of the user, such as background knowledge and linguistic skills, as well as considering task and system features. This is particularly important as the amount of scent perceived by a user is affected by a wide range of factors as shown by standard information retrieval models [12-14]. A synthesized version is shown in figure 1.

When users decide how to navigate an IIS system they choose between:

- browsing: defined as following links, typically found on menus or navigation pages;
- searching: entering a query in an on-site search box or tool.

In addition to choosing how to navigate, users must also choose which link to follow, or what query terms to use. Information scent is a key determinant in this process [15]. It provides a unified framework for examining and combining the complex relationships between user, system and task factors.

According to the model, a user given a particular task to perform using a specific system will need to establish the information needs for completing the task. Having established this, the user will select the most appropriate action or method of navigating the system to find the relevant information. The execution

and evaluation of the action will provide additional information to inform further action selection and information needs analysis as required.

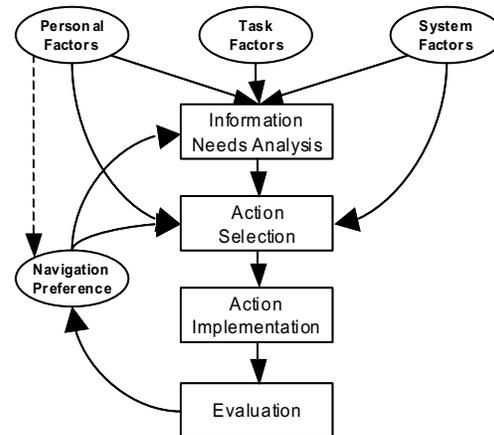


Figure 1. A model of IIS navigation

Our study provides four different types of information that relate to the model of IIS navigation and the factors that determine users ability to perceive scent:

- level 1: user characteristics (personal factors) background knowledge and skills that may affect action selection
- level 2: user behaviour (action selection) first choice of action (i.e. browse or search), number of actions of each type taken, and action taken immediately before finishing the task (necessary for calculating the success of each type of strategy).
- level 3: task outcomes (evaluation) how long tasks take, whether the required information is found, and user ratings of ease and expectation of outcome, i.e. was the product found where they expected it would be.
- level 4: navigation capabilities (preferences) confidence in browsing abilities and search tool effectiveness.

In this paper we present an investigation into task outcomes and user perceptions of them. This allows us to focus on how outcomes of the behaviour affect perceptions of ease of use. This corresponds to level 3 of the navigation model.

By forcing participants to use a variety of different navigation strategies we can assess the relationship between scent and usability of a system under different task conditions, e.g. browsing or searching. The role of

scent in *determining* behaviour (i.e. level 2 factors that lead users to choose particular action) is considered elsewhere [16].

3. Methodology

In this section we explain the methods we have used to answer the following research question: is perceived scent a predictor of perceived ease of use?

The study used an Internet shopping application to investigate the relationship between information scent and usability. The application was a web site developed by a large high street retailer to sell cosmetics and toiletries. Two experiments were performed with a single group of participants as described below. The first experiment assessed participants' dynamic perception of scent received while navigating the trial site. The second experiment assessed participants' static perception of scent based on a paper exercise.

3.1 Participants

Thirty participants were recruited from the University of Hertfordshire. These participants consisted of 18 students and 12 staff. Participants responded to an email request for volunteers. Consequently the sample is self-selecting. Volunteers were screened to ensure a mixed sample of participants with regard to age (with a median value in the 26-35 range), and gender (60% male, 40% female). Additional information on participants experience was gathered through a pre-test questionnaire.

The pre-test questionnaire showed that participants were generally experienced Internet users (over 75% had more than 4 years Internet experience) with an even distribution of preferred navigation style. (36% favoured search compared to 40% for browsing). Relevant shopping experience was more likely to be off-line (over 75% made more than two similar purchases each month) rather than on-line (over 70% had not made similar purchases on-line). Exposure to the retailer's product range was varied: 40% of participants had visited the retailer's high street stores less than once a month and 10% had never visited. 75% of participants had never visited the website.

3.2 Task design - Experiment 1

Five different tasks (A-E) were used to investigate our research question. This would ensure that all user navigation styles and task preferences would be accommodated within the study. Each task required the user to locate a product on the web site. Each task

started from the home page (a screen shot of this is provided in appendix 1). The home page includes top-level product categories of beauty, healthcare, baby, gift and mens products. An on-site search box was also clearly visible.

The tasks required participants to:

- Task A: find a single specific product, with no navigational constraint.
- Task B: find a product of a specific type, (one of over ten specific products would satisfy this goal) with no navigational constraint
- Task C, D & E: find a single specific product using a specified navigation method

In tasks C, D & E participants were directed to use a different navigation strategy for each task including: just browsing, just searching, and assisted browsing. Assisted browsing is similar to the method described by Olston and Chi [11] and involves a combination of searching and browsing. By randomizing the presentation strategy for each participant, it was possible to ensure that all styles and preferences would be controlled for in the study.

An important consideration in designing this experiment was users' previous experience of online shopping in general, and specifically their experience of shopping online with the retailer and shopping in the retailer's high street stores. In order to allow for this, participants were asked to record their previous experience of these factors in a pre-test questionnaire.

The independent variables (IVs) involved in the study were as follows:

1. Age
2. Gender
3. Internet Experience (rated on a 5 point scale)
4. Experience with the retailer online (rated 1-5)
5. Experience with the retailer stores (rated 1-5)
6. Preferred navigation method (1-5)

In order to investigate task outcome influences on perceptions of ease of use, the following dependent variables (DVs) were measured in the study:

1. The proportion of tasks completed successfully
2. Task time or duration (measured in minutes)
3. User perception of ease of task completion (1-5 Likert type scale)
4. Whether the target item was in the expected place (1-5 Likert type scale)

To collect this data (excluding DV 2) a paper-based questionnaire was used by participants during experiment 1 (shown in appendix 2). To facilitate the randomized ordering of tasks and allocation of navigation strategy the questionnaires that were produced were tailored to each individual participant.

To measure user perception of ease of task completion, a post-test questionnaire was administered which included a set of task feedback questions to assess participant perceptions of task performance. The questions asked how easy they found it to complete the task, and whether they found the answer in an expected location. The expected location question was intended to assess the participants' perception of the information scent for that task as described above.

Participant behaviour during the set tasks was also recorded through the use of Camtasia "screen cam" software which recorded all on-screen activity as an AVI movie file. In addition, customized data logging software recorded the start and completion times for each task, thereby allowing task duration (DV 2) to be calculated. The combination of video and log data allows for a detailed, action-by-action analysis of user behaviour. This corresponds to level 3 in the navigation model as discussed in section 2. This data is not considered here.

3.3 Task design - Experiment 2

In this experiment, a paper-based product location test was used to investigate conclusions about the validity of the assumptions for experiment 1. The aim was to test participants' ability to locate products in the trial site under two different conditions to isolate the effect of information scent.

In the experiment, participants were presented with a list of ten products which they had to match to the top-level categories from the website described in experiment 1. In this study of the ten product types, five were actually present in the trial site, and five were "phantom" products that were not. This represents a development of previous product location tests in which only a single condition was used [15]. The presentation of the products was randomized to reduce bias as far as possible.

A questionnaire was designed to see how well participants could judge the most relevant category, i.e. how well they could perceive the scent for a particular task. This questionnaire is shown in appendix 3. Participants were asked to rate their confidence in their ability to locate the product.

For the real products, the confidence level may have been based on actual observation of the product during experiment 1 as well as any scent perceived from the top-level categories during experiment 2. Anecdotally this is supported by several users spontaneously volunteering that the product had been seen in experiment 1. For phantom products, the confidence

assessment could only be based on a semantic match between product and possible categories, i.e. on the perceived information scent.

The experimental materials and procedure for both experiments were piloted with four test subjects prior to completion with the thirty participants to ensure that an appropriate range of behaviour was observed. The pilot data has been excluded from any analysis.

3.4 Procedure

Participants were briefed on the purpose and conduct of the experiment prior to the administration of the pre-test questionnaire. This included fulfilling the University's standard ethics policies on confidentiality, withdrawal and consent. Experiments 1 and 2 were then conducted sequentially for each participant.

In experiment 1 participants were asked to behave as they normally would during the test and were not asked to use a "think-aloud" procedure as this might be a distraction, and alter their perception of the trial site and/or their own behaviour. Prior to each task, participants were asked to read the task description aloud and their understanding of the task was verified. If the task required the use of the assisted browsing strategy, this was briefly demonstrated to the user using a single test product.

Once participants started a task they were allowed to continue until they either completed the task successfully or abandoned it. During this time the experimenter was not permitted to interact with the participant although spontaneous remarks were recorded. The participant was directed to complete the task feedback questions after each individual task was completed. The users were also prompted to provide additional feedback through a standard set of open questions designed to provide insight into how they made particular navigation choices.

For experiment 2 participants were briefed and then directed to complete the product location test at their own speed. The study, including both experiments, lasted approximately forty-five minutes for each participant.

4. Results

In the following section, the results of both experiment 1 and experiment 2 are presented along with statistical analysis. This was performed using the SPSS version 11.5 software package.

Table 1. Summary of correlations for experiment 1

Table showing the significance (P) of any relationships between the scores obtained in the experiment. ¹ = one-tailed, ² = two tailed										
	Age	Gender	Exp Internet	Exp Online	Exp High St.	Nav Pref.	Com %	Task Time	Ease Use	Target Exp
Age	*	0.197	0.988	0.191	0.250	0.030	0.222	0.457	0.168	0.126
Gender	*	*	0.035²	0.105	<0.001₂	0.252	0.212	0.500	0.799	0.266
Experience Internet	*	*	*	0.671	0.299	0.413	0.304	0.894	0.448	0.536
Experience Online store	*	*	*	*	0.011²	0.839	0.039¹	0.397	0.915	1.000
Experience Real store	*	*	*	*	*	0.940	0.812	0.445	0.561	0.298
Navigation preference	*	*	*	*	*	*	0.121	0.130	0.031²	0.059
Task Completion	*	*	*	*	*	*	*	0.001²	0.037²	0.039²
Task Time	*	*	*	*	*	*	*	*	0.385	0.523
Ease of Use	*	*	*	*	*	*	*	*	*	<0.001₂

4.1 Experiment 1

Friedman’s test for non-parametric data was used to investigate the significance of any differences in the mean values obtained for the data presented in appendix 4. No significant differences in performance or attitude were found (p>0.05).

In order to investigate any relationships that might exist between the variables in the study, a Kendall’s Tau Correlation test for non-parametric data was performed. The results of this test are summarised in table 1 above.

Significant relationships between the variables were found and are emphasized (in bold text) in table 1. These include significant correlations between the following task outcome variables:

- ease and user expectation of location (at 1% significance level)
- ease and task completion (at 5% level)
- time and task completion (at 1%)
- expectation and completion (at 5% level)

To eliminate potential third variable problems, partial correlation tests were performed. The results of these tests are summarised in table 2 below. The significant partial correlations are highlighted in bold.

Table 2. Partial correlations for experiment 1

Table showing relationships between DVs				
		Expect.	Comp.	Time
Task Comp.	<i>r</i>	.337	*	*
	Sig.	.013		
Task Time	<i>r</i>	-.121	-.464	*
	Sig.	.184	.001	
Ease	<i>r</i>	.537	.340	-.178
	Sig.	.000	.011	.089

A significant correlation between perceived ease of use and user expectations of location was found using this test. This represents stronger evidence of support for our research question.

The remainder of the correlations that are significant using the test summarised in table 1 are not significant using the more rigorous test summarised in table 2. This implies that the significance of other observed correlations between the level 3, task outcome variables is largely due to the correlation between location expectation and ease of use.

4.2 Experiment 2

Table 3 contains a summary of participant responses relating to their confidence in locating product items and of performance in experiment 1.

Table 3. Mean data for experiments 1 and 2

Summary of performance data from experiment 1 and for user confidence data from experiment 2		
	Mean	Std. Dev
Task Outcomes		
Completion	0.805	.277
Time	2.89	1.516
Expectation	2.96	.842
Ease	3.13	.938
Product Location		
Real confidence	86.2	9.880
Phantom confidence	60.0	19.671

A Kendalls Tau Correlation test was performed on the data summarized in table 3 for the real and phantom confidence variables. The results are shown in table 4.

Table 4. Correlations for experiment 2

Table of Kendall's correlations (two-tailed) for the data summarized in table 3		
Task Outcome Variable (DV)	Real Confidence	Phantom Confidence
Completion	.408	.112
Time	.157	.360
Expectation	.050	.003
Ease	.230	.053

Partial correlation tests, as with experiment 1, were performed on the (potentially) significant relationships summarised in table 4. The results of these tests are summarised in table 5 below with significant partial correlations highlighted in bold.

A significant correlation between expected location and phantom confidence was found using this test. This is very important as it shows that the measure of perceived scent for experiment 1 (i.e. expected location) is correlated with the measure of perceived scent for experiment 2 (i.e. phantom confidence). This provides support for the validity of our measures as discussed below.

Table 5. Partial correlations for experiment 2

Table showing relationships between DVs			
		Real Confidence	Phantom Confidence
Ease	<i>r</i>	-.148	.185
	Sig.	.451	.345
Expectation	<i>r</i>	-.052	.450
	Sig.	.397	.008

5. Discussion

The results from experiment 1 provide an answer for our research question. They show that for this study user expectation is a significant indicator of ease of use. They also show that user expectation is a better indicator than either task completion rate or time to completion for this study.

Assuming that measuring user expectation is an appropriate method to assess perceived scent, the results from experiment 1 support the hypothesis that perceived scent is a good predictor of ease of use for IIS. In section 5.1 we justify this assumption and in section 6 we describe how this result can be used in the practical development of high quality Internet information retrieval systems.

5.1 Assumptions of Validity

The conclusion that perceived scent is a good predictor of ease of use is based on the assumptions that:

- **A1:** expectation drives perceptions of ease of use, rather than the opposite;
- **A2:** user expectations are a good method for measuring perceived scent.

The results from experiment 2 supports assumption 1, given there is no significant correlation between phantom confidence and ease of use. In other words, it provides evidence that participants found the system easy to use because they found information where they were expecting it to be located. If the opposite were true, i.e. users said answers were in the expected location *because* they found the task easy, then the data should show that users who found browsing easy to be more confident in their location of phantom products. However, this effect has not been observed.

Combining the results from experiments 1 and 2 shows a significant relationship between the separate measures of perceived scent used in each experiment. This provides evidence to support assumption 2, i.e. the measure for experiment 1 is valid. This is inferred

from the support in the literature for the measure in experiment 2, and the correlation between the two measures.

5.2 Applicability of Results

This study relates to a single site and any claims are therefore limited in nature. In particular it is surprising that there is not a more significant relationship between task completion, task duration and perceived ease of use.

An explanation for the lack of a significant time or completion effect is that these effects are masked by experimental factors. In particular, it is possible that participants persisted with the tasks in experiment 1 longer than they normally would, and put in additional effort to complete the task. This could distort the results, although the mechanism by which this would happen is unclear.

An alternative explanation is that the interaction between factors that determine ease of use changes between systems and tasks. As participants are unfamiliar with the trial system, they could be discounting task duration as factor in their perceptions of ease of use.

There is some evidence to support changing importance of factors from the previous study conducted by the authors. This was conducted using 16 participants of a corporate intranet system. In this study expectation of information location was correlated with ease of use although task duration and completion were more significantly correlated. A third version of this study is in progress using a digital library application as the trial system.

Additional evidence of the trade-off between time and usability can be seen in "ramping interfaces" [17] where a system interface provides a little more information at each stage of a navigation process. Although this style of interface increases the time and/or cost (in terms of mental effort or attention) they are designed to provide strong cues (i.e. scent) about what each step entails.

6. Conclusions

Information scent is an important factor for understanding how users navigate complex information systems and for assessing the usability of such systems. However information scent is difficult to measure directly. The value of the information (a characteristic element of scent) gained from a system is influenced by interacting factors relating to the user, the task and the system. Many of these factors are themselves difficult to measure objectively. By

measuring user perceptions of scent our approach sidesteps many of these issues.

The major contribution of our work is the two different measures for perceived scent that have been developed and validated during this study as a means of enhancing usability:

M1: user expectation of information location is

- derived from direct user experience of a system;
- captures dynamic scent, i.e. users perception built up from examination of sub-levels in an IIS;
- incorporates system design elements, e.g. page layout and highlighting features, as well as semantic structures, e.g. site division labels.

M2: user confidence of information location is

- derived from a paper based trial;
- captures static scent, i.e. is based on examination of one level of an IIS, unsupported by exploration;
- only assesses semantic structures.

It should be noted that although M1 and M2 were used by the same group of subjects in this study, they could be used separately by different groups of assessors at different times. A separate validation exercise is being planned to assess the results of doing this.

The methods used to measure perceived scent could be applied without modification to a wide range of existing IIS already deployed or in development. In addition, a combination of these methods could be incorporated into existing analysis, design and implementation processes of an IIS. This could be done as part of an overall IIS development process [18], an IIS navigation systems design [19] or existing IIS usability evaluation techniques [20].

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Appendix 1. Trial Site Home Page

Home | Help | Login | Register | My basket | My account | Quick shop Search Go

Choose a department **Christmas** Beauty Baby Healthcare Mens Offers

Directory

Site information
 Product recalls
 Where's my order?
 Delivery info
 Privacy & security

Other departments
 Diet & fitness
 Holiday & travel
 What's new

In Christmas
 Quick shop
 Gift guide launch
 Gift experiences
 Home entertainment
 Gift boxing

In Health today
 Diet and Fitness
 SAD
 BMA health advice
 Flu 2002

In Beauty today
 Selected fragrances
 save up to 1/3
 Electrical items

Christmas online
 It's never been so easy... pick up our Gift Guides and shop online with **Quickshop**

3 for 2 Selected Trevor Sorbie hair styling

Extra Points with selected Bourjois

Extra Points with selected Lotions & Potions

Not socks again! Find the perfect gifts for everyone with our online Gift Selectors

3 for 2 Mix & Match offer

Please scroll down

Create a Christmas gift
 Click here for details

Free standard delivery when you spend over £30
 Click here for details

Buy 1 get 1 free Selected Vitamins

Edgar Elephant hobby horse £20

Gift Experiences 27 Experiences to choose from

Top 10 Gift Ideas camera gold party pack £19.99

What kind of shopper are you?
 Click here for details

What's New?
 Click here for details

Appendix 2. Task Briefing and Questionnaire

Task Instructions

Please read the following instructions which are to be followed when undertaking each task:

1. Before starting the task read the task brief out loud - please ask if anything is not clear.
2. Enter your user and task details on the task timer which you can find at the top of the screen.
3. When ready to start, start the task timer by pressing the green button.
4. Complete the task according to the brief. There will be an answer in the site that matches the brief although you may find it difficult to locate it.
5. Stop the task timer by pressing the red button when either you have found an answer that matches the brief or you wish to stop looking.
6. After each task, please complete the feedback questions for that task.

Task 1

Brief

Find some Calvin Klein "ck one" deodorant, starting from the home page.

Feedback

- A. Did you complete the task successfully? Yes No
- B. How easy did you find it to complete the task?
 Very difficult Very easy
- C. Was the answer where you expected it to be?
 Unexpected category or search results Obvious category or search results

Appendix 3. Product Location Questionnaire Extract

Product Location

Based on your experience of navigating the trial site, choose the category where would you most expect to find each type of product listed below.

Using a percentage figure, indicate in the right-most column how confident you are that the product would be in that category – 100% = absolute confidence 0% = no confidence

Product	Categories					Confidence
	Health	Beauty	Mother & Baby	Xmas / Gift	Mens	
toothpaste						
allergy products						
stocking fillers						
baby bath						
condoms						
sun glasses						

Appendix 4. Summary of mean data for experiment 1

Summary of the mean data obtained in experiment 1 N=30					
Condition	(freq)	Tasks Complete (%)	Time to Complete (Mins)	Ease of Use (1-5)	Target Expectation (1-5)
Overall		72.8	2.84	3.39	3.19
Age					
2 = 18-25 years	(12)	0.78	2.73	3.60	3.50
3 = 26-35	(3)	0.73	2.97	3.53	3.20
4 = 36-45	(4)	0.65	2.58	3.30	2.75
5 = 46-55	(7)	0.71	2.83	3.37	3.23
6 = 56-65	(3)	0.67	3.40	2.87	3.00
7 = > 65	(-)	-	-	-	-
Gender					
1 = Male	(18)	69.5	2.94	3.35	3.09
2 = Female	(12)	77.8	2.67	3.44	3.34
Internet Experience					
1 = > 1 yr	(-)	-	-	-	-
2 = 1-2 yr	(-)	-	-	-	-
3 = 2-3 yr	(7)	0.69	2.78	3.54	3.31
4 = 3-4 yr	(9)	0.71	2.96	3.51	3.33
5 = > 4 yr	(13)	0.77	2.76	3.29	3.15
Retail Online Experience					
1 = never	(23)	0.70	2.91	3.83	3.20
2 = < 1 a month	(5)	0.88	2.33	3.68	3.20
3 = 1 a month	(2)	0.80	2.78	3.00	3.20
4 = 2 a month	(-)	-	-	-	-
5 = > 2 a month	(-)	-	-	-	-
Retail Store Experience					
1 = never	(3)	0.73	3.64	4.13	3.80
2 = < 1 a month	(12)	0.73	2.71	3.30	3.13
3 = 1 a month	(3)	0.73	2.46	3.33	3.47
4 = 2 a month	(4)	0.65	3.01	3.15	2.95
5 = > 2 a month	(8)	0.78	2.66	3.45	3.10
Navigation Preference					
1 = Always Browse	(6)	0.667	3.26	2.87	2.73
2 = More Browse	(6)	0.667	2.75	3.17	3.20
3 = Equal Browse/S	(7)	0.771	2.70	3.71	3.40
4 = More Search	(7)	0.771	2.97	3.63	3.11
5 = Always Search	(4)	0.800	2.08	3.65	3.70