

Characterizing the Effect of Consumer Familiarity with Health Topics on Health Information Seeking Behavior

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Despite the growth of Consumer Health Informatics (CHI) websites, searching for relevant health information remains a challenging task for most users, especially for the consumer of non-medical professionals. Most consumers only have vague idea and cannot describe their health situation clearly due to lack of medical knowledge; therefore consumers' query keywords often do not accurately reflect their health information needs. The diversity of consumer familiarity with health topics also leads to frustration since the information presented may fall outside the consumer's comprehension level. This paper aims to investigate the effects of consumers' familiarity on their health information seeking behavior. We conducted a user study with four health search tasks. This study analyzes several characteristics of search behavior, such as query keywords, query reformulation pattern, and search strategy. The query keywords submitted by the participants are classified into general and medical terminology by matching them with Consumer Health Vocabularies and Medical Subject Headings. The identification of query reformulation pattern addresses both syntax and semantic changes. The preliminary user study findings show that participants performed different query reformulation patterns for the familiar and non-familiar tasks. For future research, the findings from this study will be used to build an adaptive CHI system.

1. Introduction

Despite the growth of Consumer Health Informatics websites and medical search engines, searching for relevant and understandable health information remains a challenging task for most consumers (nonmedical professionals). The consumers are patients and their family or friends, caregivers, and other people who concerned about their health. Searching for health information requires a certain degree of cognitive effort from query formulation to understanding the selected result. Most consumers only have vague idea and cannot describe their health situation clearly due to lack of medical knowledge. Frequently, the consumer's query keywords do not accurately reflect their information needs. After obtaining the result from a search engine, selecting the appropriate document is also problematic for lay consumers since the information on medical domain varies from the simple general article to one that requires expert level to comprehend.

When searching for health information, different consumers may have different needs. Besides consumers' interest, consumer's background knowledge of health domain (familiarity) affects the searching needs as well. As an illustration, a consumer who looks for "irregular heartbeat" information may have different needs with consumer who searches for "atrial fibrillation", although both keywords refer to the same semantic meaning. The diversity of consumer familiarity leads to frustration since the information presented may fall outside the consumer's comprehension level.

This paper aims to investigate the effects of consumers' familiarity on health information seeking behavior. The findings from this study will be used to develop an adaptive Consumer Health Informatics system. This paper is organized as follows.

Section 2 presents related studies of health information seeking behavior, query reformulations, and user's topic familiarity in information searching. Section 3 elaborates the research design. Section 4 discusses the result and analysis. Finally, section 5 concludes this preliminary study and describes the follow-up works.

2. Related Studies

2.1 Health Information Seeking Behavior

The emergence of e-patient has encouraged people of non-medical professionals to be more proactive and responsible for their own and families' health. As more consumers are progressively searching health information online, many researchers conducted studies of health information seeking behavior among the consumers. The research works encompassed observation on searching strategy, query construction, and evaluation of the search process.

Most consumers started their searches with general search engine [Efthimiades 2009, Eysenbach 2002]. When formulating health-related query, most consumers experienced difficulties due to limited understanding on medical terminology [Zeng 2006, Zhang 2012]. Most consumers submitted relatively short queries, about 1-3 terms in an experimental study of MedlinePlus [Zeng 2002, Zhang 2012]. During a search session, consumers tended to reformulate their queries to obtain more relevant result. This aspect is important because it reflected the progress of consumers' understanding. In a study of health information searching behavior in MedlinePlus website, Zhang et al. reported 85% of the query reformulations occurred as conceptual changes; specification was the most frequent pattern, followed by generalization and switching topic [Zhang 2012]. In selecting the search result, the URL and summary [Toms 2007], certain keywords and source identifiers [Sillence 2004] were used to

assess the most appropriate result. Participants in several studies considered government, pharmaceutical, and associations for medical professionals' websites as reliable sources [Toms 2007, Zhang 2012].

2.2 Query Reformulation

The sequence of query formulation and reformulation reflects the interactions between the user and the Information Retrieval (IR) system. The IR system can understand user's knowledge structure, intention, and tasks based only on query characteristics [Rieh 2006]. Information about the user is important to provide advanced adaptation and to retrieve more accurate search results.

In online information seeking, users use various types of query reformulations. Rieh and Xie characterized web query reformulations as having three facets: content, format, and resource [Rieh 2006]. They reported that 80.3% of query modifications involved content modifications. There are four types of content modification: specification (specify the meaning of subsequent query by adding more terms or replacing terms with more specific meaning terms), generalization (generalize the subsequent query by deleting terms or replacing terms with more general meaning terms), replacement with synonyms (replace terms in the previous query with words that share similar meaning), and parallel movement (the previous query and the subsequent query deal with different aspect of one concept). They also examined patterns of query reformulation based on analysis of sequences of multiple queries: generalized, specified, parallel, building blocks, and dynamic pattern.

In another research work, Boldi et al. classified query reformulations using two dimensions taxonomies: the generalization-specialization axis and dissimilarity axis [Boldi 2009]. The first axis depicts the reformulation between more general and more specific query, while the second axis portrays the change in syntactic and semantic between two queries from Same Query, Error Correction, Equivalent Rephrasing, Parallel Move, to Mission Change pattern.

2.3 User's Topic Familiarity on Information Searching

Numerous works have been conducted to study the relationship between user's topic familiarity and search effectiveness. Searchers with greater familiarity with searching topic use more varied and more specific vocabulary [Vakkari 2003], use specific searching strategy [Bhavnani 2002, White 2009], and achieve better search efficacy [White 2009]. In medical domain, it is necessary to analyze the familiarity attribute, as vocabulary gap is the main obstacle in performing health information seeking. White et al. identified expertise on medical domain based on queries and site selection [White 2009]. The expertise identification enables the system to provide more relevant query suggestions and site recommendations to non-expert consumers and to personalize search result based on expertise. In another work, Zeng et al. proposed a method that predicted consumer familiarity with health terms using contextual information [Zeng 2008].

3. Research Design

A total of 10 volunteers from undergraduate students, graduate students, and postdoctoral researcher of Osaka University participated in this preliminary study. All participants had six or more years of using the Internet in daily basis and had searched for medical information online on monthly basis or as needed. The most searched health topic was information about specific disease and health problem. This result is in conjunction with previous findings from Pew Internet survey in 2012 [Ref]. The participants were asked to complete four tasks, as listed below:

- Task 1 – Exploratory Task: For the last three days, you have been experiencing intense painful swelling and redness in your right big toe. You want to find out what may happen to your big toe and how to treat it.
- Task 2 – Specified Task: Your close friend has been diagnosed with rheumatoid arthritis. He/she hesitated to take some of the prescribed-drugs because he/she heard that certain drugs used to treat rheumatoid arthritis have potentially serious side effects, such as osteoporosis. You want to know the relation between rheumatoid arthritis and osteoporosis, how they affect each other, and which treatment of rheumatoid arthritis that would not lead to osteoporosis or at least decreases significantly the possibility of osteoporosis.
- Task 3 – Specified Task: Your doctor prescribed hydrochlorothiazide and told you not to consume any decongestant drugs during the medication. You want to know detail about hydrochlorothiazide and why it should not be taken together with decongestant drugs.
- Task 4 – Personalized Task: Lists two of generally recommended treatments for a health-related matter, disease, or symptom that (i) interest you, or (ii) become your concern.

The participants were free to use any search engines (both general and medical specialized), access to any relevant websites, and search at their own speed. Upon the completion of each task, the participant rated the searching performance, the cognitive effort required to complete the task, the difficulty and the familiarity of the task; all on a 5-likert scale. The participants were asked to explain his/her searching strategy as well. After the completion of all search tasks, the participant was questioned about his/her impression on the search process. All the search sessions were recorded using screen and audio capture tools.

4. Result and Discussion

4.1 Perception of Tasks

The participants spent between 43 minutes to 70 minutes to complete four searching tasks. All participants spent averagely 70% of their time to finish Task 2 and 3. Based on participants' rating, both tasks were more difficult than other tasks. Task 2 was significantly more difficult than Task 1 or Task 4. Similarly, Task 3 was significantly more difficult than Task 1 or Task 4. In term of familiarity, participants were most unfamiliar with health terminologies on Task 2 (*rheumatoid arthritis* and *osteoporosis*) and Task 3 (*hydrochlorothiazide* and *decongestant drug*). The terms in Task 2 were significantly more unfamiliar than terms in

Task 1 or Task 4. Similarly, Task 3 was more significantly unfamiliar than Task 1 or Task 4.

Table 1 shows the participants' perception of the tasks, including searching performance, cognitive effort to complete each task, difficulty of each task, and the familiarity with health terminologies on each task.

Table 1 Mean Perception of the Tasks

Task	Searching Performance ⁱ	Cognitive Effort ⁱⁱ	Difficulty ⁱⁱⁱ	Familiarity ^{iv}
1	4.44 (0.53)	2.22 (1.30)	1.78 (0.83)	1.78 (0.67)
2	3.56 (1.24)	3.89 (0.78)	3.78 (0.67)	4.67 (0.50)
3	3.56 (1.42)	3.56 (1.42)	3.33 (1.41)	4.56 (0.53)
4	4.22 (0.67)	2.22 (1.20)	1.89 (0.33)	1.56 (0.53)

ⁱ 1: very disappointed - 5: very satisfied;

ⁱⁱ 1: very small amount - 5: very large amount;

ⁱⁱⁱ 1: very easy - 5: very difficult;

^{iv} 1: very familiar - 5: very unfamiliar

4.2 Searching Behavior

The searching behavior section presents the result and discussion about query attribute and search result interaction.

(1) Query Attribute

Participants submitted a total of 97 queries in 36 search sessions. The average query length was 3.62. The detail of query attribute is shown in Table 2.

Table 2 Query Attribute: Number of queries and terms

Task	Total queries (Average per Task)	Total terms (Average Query Length)
Task 1	14 (1.56)	53 (3.79)
Task 2	28 (3.11)	120 (4.29)
Task 3	32 (3.56)	101 (3.16)
Task 4	23 (2.56)	72 (3.13)

Participants submitted a total of 125 queries in 40 search sessions. The average query length was 3.74. The detail of the query attribute is shown in Table 3.

Table 3 Query Attribute: Number of queries and terms

Task	Total queries (Average per Task)	Total terms (Average Query Length)
Task 1	15 (1.50)	53 (3.53)
Task 2	46 (4.60)	198 (4.30)
Task 3	35 (3.50)	125 (3.57)
Task 4	29 (2.90)	91 (3.14)

Task 3 had the most submitted queries, followed by Task 2. Participants encountered difficulties in formulating the query and selecting fitting result on both tasks due to the unfamiliarity with health terminologies. For the query length, Task 2 had the longest average query length, followed by Task 1 and Task 3. Task 1 had longer query length than Task 3 because the participants included more stop-words (e.g. and, in, the) in Task 1's queries.

(2) Search Results Interaction

All participants accessed Google search engine as the starting point. None of the participants used medical specialized search engine. Participants accessed for a total of 246 results with following detail: 64 webpages for Task 1, 65 webpages for Task 2, 47 webpages for Task 3, and 70 webpages for Task 4. The participants mainly accessed the results from the first result page. Only one participant accessed the second result page.

4.3 Effects of Consumers' Familiarity on Searching Behavior

The main challenge in health information seeking for consumers is limited understanding on medical domain. Most consumers are not familiar with health / medical vocabulary. An important remedy for this problem is how to estimate the consumers' familiarity so that a health information retrieval system can provide better assistance and present more understandable results. Towards that goal, this study investigates the effect of consumers' familiarity on searching behavior, which includes query keywords and query formulation and reformulation pattern.

(1) Query Keywords

The query keywords in health domain can be classified into common consumer term and medical specified term. The common consumer term contains general and everyday health terminologies such as painful, broken bones, heart attack, and hair loss. The medical specified term applies to set of vocabulary to describe human body and its associated component in a medical science based manner. In this study, Task 1 used common consumer terms to simulate a general health problem situation, while Task 2 and Task 3 featured medical specified terms, such as rheumatoid arthritis, osteoporosis, decongestant, and hydrochlorothiazide.

The majority of query keywords for Task 1 - 3 were from the task descriptions; therefore the type of the query keyword followed the classification of terminologies in each task. Unlike the preceding tasks, the query keywords for Task 4 were recalled from the participants' understanding, either based on their interest or concern. Those query keywords were then categorized into common consumer term and medical specified term. We developed a program to automatically perform keywords classification using a controlled medical vocabulary thesaurus from Medical Subject Headings (MeSH). Of all 29 queries issued, 24 of them (82.76%) contained phrases from MeSH database, for example alopecia, tinnitus treatment, back pain diagnosis, diabetes mellitus prognosis, and peptic ulcer treatment. This result indicated that searchers' use more specific and more varied vocabulary in more familiar task. Their vocabulary overlapped slightly with defined thesaurus.

(2) Query Reformulation Pattern

The first query in a health information search session represents consumer's initial understanding of a health problem. As his/her understanding develops, the consumer reformulates the query to obtain more relevant result. This reformulation involves syntactic and semantic changes. The analysis of query

reformulation in this study examines the entire sequential query formulations in a single search session and adopts query reformulation pattern model from Rieh and Xie [Rieh 2006]. Detailed definition of the pattern and the examples are given in Table 4.

Table 4 Query Reformulation Pattern and Examples

Pattern	Definition and Example
Generalized	User generalizes the meaning of previous query through successive trials in a search session. Example: heart attack symptom → heart attack → heart disease.
Specified	User specifies the meaning of previous query by adding more terms and combining concepts. Example: rheumatoid arthritis → rheumatoid arthritis and osteoporosis → rheumatoid arthritis treatment without osteoporosis effect.
Parallel	User modifies the queries in a search session from one aspect of a concept to another. Example: epilepsy symptom → epilepsy blood test diagnosis → epilepsy treatment.
Building Block	User combines the concepts from the previous queries and uses them in subsequent query. Example: anxiety → bipolar diseases → relation between anxiety and bipolar disease.
Dynamic	User performs inconsistent reformulation pattern from one pattern to another pattern in a search session. Example: hypertension → hypertension and diabetes → hypertension causes → diabetes mellitus → diabetes leads to hypertension.

In Task 1, only three participants reformulated their queries. Other participants issued single query and relied on exploring the search results. All three reformulation patterns were specified pattern. For example, a participant initiated the query with “pain in the big toe”, then reformulated to “pain redness in the big toe” and “pain redness in the big toe treatment”.

In other tasks, all participants reformulated their queries. As shown in Table 5, majority of participants performed dynamic pattern in Task 2 and Task 3. An example in Task 2, a participant initiated the query with “rheumatoid arthritis” then specified it to “rheumatoid arthritis causes osteoarthritis” and replaced the word “causes” with “affects” in the next query (“rheumatoid arthritis affects osteoarthritis”). This participant assumed that osteoporosis and osteoarthritis referred to the same disease. Then, the participant changed the query into “rheumatoid arthritis drug side effect” and specified the keywords in the last query into “rheumatoid arthritis drug side effect osteoporosis”. In that search session, the participant executed dynamic reformulation pattern by increasing specificity and moving around from replacing with synonym to parallel movement and back to specification. In Task 4, the parallel reformulation pattern occurred in 90% of the search sessions. For example, one participant issued “alopecia areata” query then moved to

“androgenic alopecia” in his/her subsequent query and changed it to “alopecia treatment” in his/her last query.

This study result shows that participants performed different query reformulation pattern on different familiarity level tasks. In unfamiliar task, the participants performed dynamic reformulation pattern, as seen in Task 2 and Task 3. When participants had very little knowledge about the task, the participants relied only on the task descriptions to formulate the query and encountered more problems in their search. Some participants did not access any results from some of their queries in Task 2 and Task 3 because they got confused. Instead of examining the search result, they were issuing a new query by adding more words or moving into another aspect of the same concept. In more familiar task, the participants tended to perform parallel reformulation pattern, as seen in Task 4.

4.4 Implications for Consumer Health Informatics System

Searching for health information remains a challenging task for most consumers. Therefore, a CHI system or health information retrieval system should provide suitable assistance based on consumers’ familiarity. To estimate the familiarity attribute, the system can use several approaches, such as:

- Identify the classification of query keywords, using the Consumer Health Vocabulary and Medical Subject Headings to differentiate between common consumer term and medical specified term.
- Detect the query reformulation pattern automatically, Use Unified Medical Language System (UMLS) Semantic Network to analyze the semantic change in query reformulations. For example, a “heart attack” query is generalized to “cardiovascular disease” query.
- Track the site selection, Some health/medical websites, such as PubMed and Medscape, publish advanced articles for medical professionals and researchers. While other websites, such as MedlinePlus and WebMD, are specifically designed for general consumers.

5. Conclusion and Future Works

This preliminary study shows that the familiarity with health topics affected consumers’ searching behavior, such as the query formulation, the pattern of query reformulation pattern, and query keywords selection. The consumers tend to issue more specified terminology on familiar task and perform different query reformulation pattern on different familiarity level tasks. The CHI or health information retrieval system can use these features to estimate the consumer’s familiarity. The system then can provide query suggestions and site recommendations to non-expert users, and personalize the search results. As follow up to this study, we aim to conduct more data collection and to develop a prediction model of consumer’s familiarity with health topics. The predictive model will be used to build an adaptive CHI system.

Table 5 Query Reformation Pattern in Each Task

Pattern	Frequency				Example
	Task 1	Task 2	Task 3	Task 4	
No reformulation	7	-	-	-	
Generalized	-	-	-	-	
Specified	3	1	-	1	<ul style="list-style-type: none"> Pain in the big toe → [S1] pain redness in the big toe → [S2] pain redness in the big toe treatment. Rheumatoid arthritis → [S1] rheumatoid arthritis and osteoporosis → [S2] rheumatoid arthritis treatment without osteoporosis effect.
Parallel	-	-	1	9	<ul style="list-style-type: none"> Epilepsy symptom → [P1] epilepsy blood test diagnosis → [P2] epilepsy treatment. Alopecia areata → [P1] androgenic alopecia → [P2] alopecia symptom → [P3] alopecia treatment.
Building Block	-	1	1	-	Hydrochlorothiazide → decongestant → hydrochlorothiazide and decongestant interaction.
Dynamic	-	8	8	-	<ul style="list-style-type: none"> Hydrochlorothiazide → [S1] hydrochlorothiazide effect → [P1] hydrochlorothiazide and decongestants → [G1] decongestants → [S2] decongestants side effect. Rheumatoid arthritis → [S1] rheumatoid arthritis causes osteoarthritis → [R1] rheumatoid arthritis affects osteoarthritis → [P1] rheumatoid arthritis drug side effect → [S2] rheumatoid arthritis drug side effect osteoporosis.

Note: Total search sessions for each task: 10.

G: generalization; S: specification; R: replacement with synonym; P: parallel movement.

References

- [Bhavnani 2002] Bhavnani, S. K., Domain-specific search strategies for the effective retrieval of healthcare and shopping information, Proc. SIGCHI: 610-611, ACM, 2002.
- [Boldi 2009] Boldi, P., Bonchi, F., Castillo, C., & Vigna, S., From Dango to Japanese cakes: Query reformulation models and patterns, Proceedings of the 2009 IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology - Volume 01 (pp. 183-190). IEEE Computer Society, 2009.
- [Efthimiades 2009] Efthimiadis, E.N., How students search for consumer health information on the web, Proceedings of the 42nd Hawaii International Conference on System Sciences, 1-8, 2009.
- [Eysenbach 2002] Eysenbach, G., and Kohler, C., How do consumers search for and appraise health information on the World Wide Web? Qualitative study using focus groups, usability tests, and in-depth interviews, BMJ, 324, 573-577, 2002.
- [Rieh 2006] Rieh, S. Y., and Xie, H., Analysis of multiple query reformulations on the web: The interactive information retrieval context, Information Processing and Management 24, 751-768, 2006.
- [Sillence 2004] Sillence, E., Briggs, P., Fishwick, L., and Harris, P., Trust and mistrust of online health sites, Proceedings of CHI 2004, 663-670, 2004.
- [Toms 2007] Toms, E., and Latter C., How consumers search for health information, Health Informatics Journal, 13(3), 223-235, 2007.
- [Vakkari 2003] Vakkari, P., Pennanen, M., and Serola, S., Changes in search terms and tactics while writing a research proposal: a longitudinal case study, IP&M, 39(3), 445-463, 2003.
- [White 2009] White, R. W., Dumais, S. T., and Teevan, J., Characterizing the influence of domain expertise on web search behavior, WSDM, 132-141, ACM, 2009.
- [Zeng 2002] Zeng, Q.T., Kogan, S., Ash, N., Greenes, R.A., and Boxwala, A.A., Characteristics of consumer terminology for health information retrieval, Methods of Information in Medicine, 41, 289-298, 2002.
- [Zeng 2008] Zeng-Treitler, Q., Goryachev, S., Tse, T., Keselman, A., and Boxwala, A., Estimating consumer familiarity with health terminology: a context-based approach, Journal of the American Medical Informatics Association, 15(3), 349-356, 2008.
- [Zhang 2012] Zhang, Y., Wang, P., Heaton, A., and Winkler, H., Health information searching behavior in MedlinePlus and the impact of tasks, Proc. IHI 2012, ACM, 2012.