

User Involvement and System Support in Applying Search Tactics

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Both user involvement and system support play important roles in applying search tactics. To apply search tactics in the information retrieval (IR) processes, users make decisions and take actions in the search process, while IR systems assist them by providing different system features. After analyzing 61 participants' information searching diaries and questionnaires we identified various types of user involvement and system support in applying different types of search tactics. Based on quantitative analysis, search tactics were classified into 3 groups: user-dominated, system-dominated, and balanced tactics. We further explored types of user involvement and types of system support in applying search tactics from the 3 groups. The findings show that users and systems play major roles in applying user-dominated and system-dominated tactics, respectively. When applying balanced tactics, users and systems must collaborate closely with each other. In this article, we propose a model that illustrates user involvement and system support as they occur in user-dominated tactics, system-dominated tactics, and balanced tactics. Most important, IR system design implications are discussed to facilitate effective and efficient applications of the 3 groups of search tactics.

Introduction

The fundamental component of information retrieval (IR) is interaction between users and systems. To achieve a particular IR task, users need to make decisions and take

actions while interacting with different types of system features. By integrating user involvement and system support, users can effectively retrieve information from an IR system. Recognizing the interactive nature of IR, researchers have studied reciprocal relationships between user involvement and system support (Bates, 1990; White & Ruthven, 2006; Xie, 2003). Balancing user involvement and system support is closely related to effective IR process, and the design of IR systems should consider the extent to which users should play a role and to which systems should support users in the search process.

In this study, user involvement is defined as a series of cognitive processes and behavioral activities that users perform to accomplish different types of search tactics in interacting with IR systems. System support is defined as a variety of system features that function on the users' behalf or assist them to apply search tactics in the search process. Search tactics refer to a set of users' choice of search moves employed to advance the search process (Bates, 1979; Mikkonen & Vakkari, 2016; Xie & Joo, 2010a). This study focuses on the investigation of user and system roles in applying multiple types of search tactics during the search process.

In IR system design, researchers have suggested various system features optimized for different types of user involvement. In particular, they propose varying system design options that assist different levels and types of user involvement (Herrouz, Khentout, & Djoudi, 2013; Liew, 2011; Makri, Blandford, & Cox, 2008b; Mu, Ryu, & Lu, 2011; Vilar & Zumer, 2008). IR systems need to offer appropriate system support to better facilitate user involvement in

Received January 23, 2015; revised April 12, 2016; accepted May 23, 2016

© 2016 ASIS&T • Published online 0 Month 2016 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/asi.23765

different activities of the search process. In IR processes, users need to take the lead in some of the activities, but in other activities users might prefer systems to play a major role. Also, in situations where users experience difficulty, it would be better to have the system assist them (Bates, 1990). In this sense, it is important to determine how the user should be involved in the search process and how they should be supported by the system (Xie, 2003).

This article presents an investigation of user involvement and system support in applying search tactics during the IR process. We empirically examined users' perceptions and behaviors in relation to search tactics in which the user's role should be greater than the system's role, and vice versa. Based on quantitative analysis, types of search tactics were classified into three groups: user-dominated tactics, system-dominated tactics, and balanced tactics (see Data Analysis for definitions). More important, we explored specific interactions focusing on user involvement and system support in applying those tactics based on qualitative data.

Literature Review

Search Tactics and the Search Process

This study explores user involvement and associated system support in applying different types of search tactics during the search process. Search tactics represent the fundamental level of user behavior in information searching. In information searching, researchers have focused on four distinct levels: search tactics/moves, search strategies, patterns, and search models (Bates, 1979; Xie & Joo, 2012). Different types of tactics play different roles in facilitating users effectively searching information. Bates (1979) classified search tactics into monitoring tactics, file structure tactics, search formulation tactics, and term tactics. Monitoring tactics and file structure tactics enable users to track the search and explore the file structure to find the desired information. Search formulation tactics and term tactics assist users to select and revise terms in search formulation and reformulation. Other researchers further analyzed search formulation tactics and term tactics, such as broadening, narrowing, searching for an author, term checks, changing, topics, error, and repeat (Shute & Smith, 1993; Vakkari, Pennanen, & Serola, 2003; Wildemuth, 2004). New search tactics emerged in the internet searching environment. Smith (2012) proposed a group of new evaluation tactics because of the nature of internet materials including context, cross-check, cachet, and audition as well as a set of navigation tactics, such as URL, hubspoke, and backlink because of the uniqueness of the interfaces on the internet.

Search tactics constitute the information search process, and each search process is comprised of a variety of search tactics. Xie (2008) identified 10 types of search tactics that users apply in the search process, including:

- Selecting databases: Identifying appropriate resources relevant to the search task
- Creating: Coming up with a search statement

- Exploring: Browsing information/items in a specific information system
- Evaluating: Assessing the relevance, usefulness and/or other criteria of search results.
- Monitoring: Tracking the search process or checking the current status
- Organizing: Sorting out a list of items with common characteristics
- Accessing: Going to a specific item or web page
- Keeping records: Saving information about an item(s) or search results
- Modifying: Changing the previous search statement
- Learning: Gaining different types of knowledge needed for effective and efficient IR

Based on previous research, Choi (2010) further highlighted four types of search tactics in the search process: query tactics (query formulation), navigating tactics (exploration), scanning (results evaluation), and extraction tactics (display and saving records). Search tactics are further analyzed with respect to the search process. Yue, Han, and He (2012) associated the search tactics, Query, View, Save, Workspace, Topic, and Chat, with a search process, such as defining a problem, selection of sources, and examining results.

Specific applications of search tactics are also investigated in different stages of the search process. Kuhlthau's (1991, 2004) information search process (ISP) posits six search stages: initiation, selection, exploration, formulation, collection and presentation with associated actions, and cognitive thoughts and feelings. Adapting from Kuhlthau's ISP, Vakkari and colleagues (Vakkari, 2001; Vakkari et al., 2003) concentrated on three stages: prefocus, formulation, and postfocus. They identified the pattern that users apply more search formulation and conceptual search tactics but less operational tactics when they advance their stages. Cole (2012) also reduced Kuhlthau's six-stage model to three stages. Prefocus is the stage where a user explores a diverse set of resources. At the focusing stage, the search is narrowed and intensified. Finally, at the postfocus stage, the search engages a more focused search statement, which leads to evidentiary and supportive information for idea or focus statement. The main contribution of Cole's work is its association of search stages with information need changes and knowledge formation. This study includes search tactics applied in all of the prefocus, focusing, and postfocus stages during the search process; it further examines the change of user involvement and system support in applying diverse search tactics during the search process.

Balancing User Involvement and System Support in the Interactive IR Process

Interactive IR system design is a matter of balancing two aspects of contribution to the IR process: to what extent a user should exert his/her effort to control the IR process; and to what extent the system should support the user to effectively and efficiently proceed to the IR process (Bates, 1990;

Xie, 2003). IR system design necessitates a choice between providing system features that require little user involvement, or more interactive features that could give users more control when using IR systems. In IR processes a user is invited to be an active participant rather than a passive recipient of and reactor to output from the system (Belkin, 1993).

User involvement can be considered one aspect of user engagement, which is directly related to users' physical behavior and cognitive process to control and interact with the system to accomplish search tactics. While user engagement is a broader concept encompassing various constructs and attributes derived from overall user experience, such as aesthetic, sensory appeal, and attention (O'Brien, 2011; O'Brien & Toms, 2008, 2010), user involvement focuses more on actual behavioral and cognitive interactions that are necessary to enact search tactics. Researchers have used different terminologies to represent user involvement, such as user control and user role. For consistency, user involvement is used in the literature review. Bates (1990) is one of the early scholars who raised the issue of balancing user involvement and system support in IR system design. She explored to what extent and in what ways a user should be able to direct the system to function on their behalf. She concluded that IR systems should support the user for effective IR. System features at different levels can optimally support users' participation. Based on Bates's (1990) suggestion, several researchers began to consider both the user role and the system role in IR processes, that is, user involvement and system support in IR system design. While addressing the problems of system-dominated systems, Hendry and Harper (1997) proposed an informal information-seeking environment where a searcher increased power over the system interface during the informal problem-solving practice. Beaulieu and Jones (1998) stressed that it is imperative to determine to what extent the user and the system should play a role in IR system design. In their review of IR system design trends over time, Savage-Knepshield and Belkin (1999) pointed out that system designers progressively increased both the level of system-side support and the level of domination provided to users in designing IR systems. Xie (2003) directly compared users' perceptions of ease-of-use versus user control. The major finding of her study was that the extent of user involvement and system support differed by search activities. She also suggested desired functionalities and interface structure of IR systems in order to support both user involvement and system support. Xie further asserted that user involvement and system support are the two essential factors that lead to effective IR. Based on their experimental study, White and Ruthven (2006) investigated what types of search activities users preferred to perform. Their results show that users tended to keep more control during search result evaluation, but wanted more assistance from the system during query reformulation.

Previous research has begun to explore user involvement and system support in the search process, and concludes that it is imperative to balance both roles in the interactive IR process.

System Support and User Involvement for Different Types of Search Tactics

Among different types of search tactics, user roles and system roles for query creation and modification have been widely explored in the IR research field. The interactions occur while IR systems are assisting users to articulate their information needs into specific search statements. In query creation and reformulation, the user role is to identify their information needs and convert them into a search statement. This involvement requires users to apply various levels of user knowledge to create and reformulate search queries, such as domain knowledge, system knowledge, and search skills (Hsieh-Yee, 1993; Hu, Lu, & Joo, 2013; Wildemuth, 2004; Zhang, Liu, & Cole, 2013). The system role should assist users to increase their levels of knowledge and to choose terms more relevant to their search goals. Imprecise queries or poor structure of search statements could yield inappropriate results, which consequently led users to interact with system features more often to find more relevant terms (Keselman, Browne, & Kaufman, 2008). At the same time, researchers have paid attention to the effects of advanced search features on user-system interactions. Vilar and Zumer (2008) proposed different levels of system support and user involvement by providing different types of search interfaces, basic search versus advanced search. They discussed the need for command searching to empower the levels of control for advanced users. Similarly, some features allow more control for users to handle queries. Researchers suggest adopting system features, such as those that allow for manipulating multiple queries, provide query feedback and suggestions, and enable query and search result tracking (Kelly, Gyllstrom, & Bailey, 2009; Rieh & Xie, 2006). System support is purposely designed for users to be better involved in query reformulation by providing query manipulation options, such as options for broadening or narrowing queries, suggesting related terms, or correcting misspellings (Zeng et al., 2006).

Researchers have also examined user involvement and system support in exploring tactics, which are essential for conducting browsing activities during the IR process. System support for exploration tactics helps users understand the organization of information, while user roles involve choosing relevant browsing categories or selecting items from a predefined document list. In prior studies, various system features were proposed to facilitate effective user involvement, such as toolbar options, footprints, structured breadcrumbs, and adaptive navigation (Wexelblat & Maes, 1999; Zeiliger & Esnault, 2008). Offering controlled vocabulary is another approach to support users with varying levels of domain knowledge (Mu et al., 2011). In addition, clear structure of information items is critical in effective user involvement. Herrouz, Khentout, and Djoudi (2013) argued that inadequate organization of information could lead to users being lost while exploring. When exploring information items, users make navigational choices and judgments, and systems should relieve their cognitive load

and increase navigation efficiency by decreasing the complexity of navigational paths (Blustein, Ahmed, & Instone, 2005; Kammerer, Scheiter, & Beinhauer, 2008).

In applying evaluating tactics, users focus on identifying multiple dimensions of criteria to evaluate search results or individual items, and the systems emphasize generating related information to support users' evaluation process (Xie & Benoit, 2013). The provision of document metadata, search results with short summaries, and categorized overviews facilitates users' efficient involvement in evaluating tactics (Kules & Shneiderman, 2008; Makri, Blandford, & Cox, 2008a). Manipulation of the results display is another way to support users applying evaluation tactics. For example, Mu et al. (2011) suggested a novel result display that integrated search facets and browsing visualization to support users' effective evaluation. They found that this type of display could increase the user's topic knowledge during the evaluation process.

A relatively smaller body of research has focused on organizing, monitoring, accessing, or learning tactics. With regard to organizing tactics, users' concern is identifying adequate organizing filters or criteria, while systems support users to organize search results or documents by providing various organization criteria (Ogilvie & Callan, 2003). As for monitoring tactics, several researchers concentrated on the tracking of search activities across successive sessions (Lin, 2005; Lin & Belkin, 2004). In accessing tactics, users are involved in the search process by clicking hyperlinks or typing URLs to go to a specific page or clicking the back button to go back to the previous page, and systems provide multiple access points for users to choose from (Xie & Joo, 2010b). In applying learning tactics, users actively interact with IR systems to gain knowledge about systems, domain, and search skills (Xie & Cool, 2009). Users' learning tactics can be supported by explicit and implicit help features in the IR systems. Explicit help, typically labeled "help," is designed to support users' learning processes in using an IR system. In contrast, implicit help features support users' learning by presenting frequently asked questions, information feedback, and search tips; researchers found that users' preferred implicit help over explicit help in learning systems (Liew, 2011; Trenner, 1989; Xie & Cool, 2009).

As reviewed, existing research has discussed user involvement and system support in the IR process, and has greatly contributed to the understanding of user involvement and the design of various system features supporting multiple types of search tactics. However, previous research has some limitations. First, little research has investigated different roles that users and systems play in applying each type of search tactic during the search process. This type of study can portray the nature of user-system interactions in the IR process. Second, only a few studies have examined various search tactics that users apply in the search process in relation to user involvement and system support. Most past studies explored only one or two search tactics or the overall search experience rather than the investigation of all key search tactics applied in the search process and associated

user involvement and system support. Most important, previous studies suggested different types of system support/features for different types of search tactics. However, few of them has addressed specifically "the extent and in what ways" the user plays her/his role in the search process and "the extent and in what ways" the system supports what the user needs or desires. That is, little research has been conducted with regard to whether user involvement or system support is more dominant or needed in accomplishing a particular type of search tactic.

Although previous research has explored both user involvement and system support in applying search tactics, there are no substantial research findings in terms of whether there is a difference between the levels of user involvement and system support, and in what ways users and systems play roles in accomplishing each type of search tactic. The proposed research questions and hypotheses (see Research Questions and Hypotheses) of this study are drawn from the limitations of previous research. This article fills in the gap that investigates what users prefer to involve, and what they expect the system to support in applying search tactics.

Research Questions and Associated Hypotheses

RQ1. Which types of search tactics are user-dominated, system-dominated, or balanced tactics?

Hypotheses (1–8):

There is no significant difference between perceived levels of user involvement and system support in applying Creating (H1), Exploring (H2), Evaluating (H3), Monitoring (H4), Organizing (H5), Accessing (H6), Modifying (H7), and Learning (H8) tactics.

RQ 2. What are the types of user involvement and system support needed in applying user-dominated, system-dominated, or balanced tactics?

Methods

Sampling

Participants of this study were recruited from the first-year graduate students in an information school at a state university in the United States (US). This study consists of two groups of participants recruited 6 months apart. The first and second group include 21 and 41 participants, respectively, for a total of 62. To maintain the privacy of the participants and integrity of their responses, each participant was assigned a number when expressing interest in participating in the study. Sixty-one of the 62 participants completed the questionnaire and the diary. Participant numbers were assigned before the participants started the study. Participant respondents were referred to as Participant 1 or (P1) when quotes are used in the findings. One of the participants (P53) did not complete the study, so data from P53 were not utilized or quoted in the findings. All other participants' quotes, from P1 through P62, were utilized.

Two main reasons underlie the selection of these students as participants: first, they had the opportunity and

experience to search for information in different types of IR systems, so they could better assess how IR systems in general support users in applying different types of tactics. We were not specifically looking for expert users since a user could have different experiences using different types of IR systems. Second, they were enrolled in the online program of the school, so they represent users in different parts of the US. In addition, they also had varying job titles, such as book seller, director of information services, instructor, journalist, legal assistant, library worker, market analyst, office administrator, paralegal, patient coordinator, program coordinator, public services assistant, retail manager, student, student services administrator, substitute teacher, system developer, webmaster, writer, etc. As such, they represent general users.

Table 1 presents the demographic characteristics of the participants. While the majority of the participants were female, they represent users in different age groups. Most of them were Caucasian, but other ethnic groups are also represented. Table 2 presents participants' usage frequency of different types of IR systems. While the majority of the participants used web search engines, online public access catalogs (OPACs), and online databases quite frequently, few of them often used digital libraries.

Data Collection Methods

Data collection methods consist of an online questionnaire and a structured 2-week diary kept by each participant. The overall data collection process took about 2 months for each group. All consent forms, questionnaires, diaries, and correspondence between the researcher and participants were transmitted via e-mail. The think-aloud protocol was

TABLE 1. Summary of demographic characteristic of participants.

Demographic characteristics		Number	Percentage
Gender	Male	13	21%
	Female	48	79%
Age	21-29	24	39%
	30-39	16	26%
	40-49	15	25%
	50-59	5	8%
	59+	1	2%
Native language	English	59	97%
	Non-English	2	3%
Ethnicity	Asian	3	5%
	Caucasian	53	87%
	Hispanic	3	5%
	Other	2	3%

TABLE 2. Participants' IR system usage frequency.

IR systems	Rarely & seldom use	Occasionally & sometimes use	Often & usually use	Always use
Online databases	5 (8%)	17 (28%)	29 (48%)	10 (16%)
Web search Engines	0 (0%)	2 (3%)	11 (18%)	48 (79%)
OPACs	4 (6%)	9 (15%)	15 (25%)	33 (54%)
Digital libraries	38 (62%)	19 (31%)	3 (5%)	1 (2%)

not used in this study because participants were online graduate students who lived in different areas of the US and would not have been able to come to the local computer lab where the think-aloud software is installed.

A diary approach was chosen because previous research demonstrated that it works with various types of user groups in collecting their search activities and associated thoughts. For example, in Xie's prior (2006) study, company employees representing a variety of departments kept an "information interaction diary" for two search tasks for a 2-week period. Sohn, Li, Griswold, and Hollan (2008) also conducted a 2-week diary study of a diverse group that explored participants' mobile information needs, the strategies, and the factors that influenced their need.

Participants were asked to sign the consent form before participating in the study. The form included Institutional Review Board (IRB) approval information for the study. It was presented online as part of the online questionnaire and was a prerequisite to participant access to the questionnaire and study materials. Second, participants were instructed to fill in the questionnaire to solicit the following information: i) their demographic information, including age, gender, native language, ethnicity/race, and profession; ii) their computer and IR system use experience, which was self-assessed by the user; iii) their typical work and search tasks for each of the four types of IR systems, the search topic, and the reason for selecting the system to perform the task; iv) their perceptions of user involvement and system support in performing different types of search tactics; and v) their assessment of four types of IR systems based on their search experience. In the online questionnaire, each participant was provided definitions of search tactics and associated examples. Participants were instructed to rate their perceptions of their need for system support and their reliance on their own involvement in applying each type of search tactic separately. Each rating used a 7-point Likert scale ranging from "1, *not at all*" to "7, *a great deal*."

Third, participants were instructed to perform one self-generated search task for each of the four types of IR systems (one online database, one web search engine, one OPAC, and one digital library). They were told to make their own choice of one IR system (e.g., Ebscohost, Google, WorldCat, American Memory) for each of the four types of systems. The only requirement was that search tasks completed exemplify the typical search tasks that they would normally perform using each type of IR system. Typical self-generated searches consisted of academic and personal tasks. The following are four examples for each type of IR

TABLE 3. Data analysis plan.

Research questions/hypotheses	Data collection methods	Data analysis method
Levels of user involvement and system support for each type of search tactic	Questionnaire	<i>t</i> -test
Types of user involvement and system support	Diary and questionnaire	Open coding Taxonomies of types of user involvement Taxonomies of types of system support

system: Search engine: “Find out if General Motors retirees are still eligible for employee vehicle discounts (P26)”; OPAC: “I am interested in finding fictions written by Jane Green (P7)”; Online database: “What are the demonstrated benefits of meditation in the treatment of depression? (P45)”; and Digital library: “I would like to find out about President Lincoln and slavery and how they were related to each other (P39).”

Fourth, participants were instructed to keep a diary to record: i) the IR system used, and ii) a description of their search topics. Moreover, they were also instructed to focus on the following search tactics: i) selecting databases/collections; ii) creating search statements; iii) reformulating search statements; iv) exploring information; v) learning system features, domain knowledge, and information retrieval skill; vi) monitoring the search process or search status; vii) organizing search results; viii) accessing an item; ix) evaluating search results; and x) keeping a record. For each tactic, the participants were asked to discuss the following: a) what they did themselves in performing each search tactic; b) what type of system support they used; c) the features they liked the most in supporting each tactic with associated reasons and examples; d) the features they disliked the most in supporting each tactic with associated reasons and examples; and e) the desired features they would like to have in supporting each tactic. A sample diary was given to each participant providing clarification on how to appropriately enter information into the diary.

Data Analysis

Table 3 presents the data analysis plan, which consists of research questions, corresponding data collection, and data analysis methods. Both quantitative and qualitative methods were employed to analyze the data. Quantitatively, we conducted *t*-tests using IBM SPSS 22.0. The *t*-tests compared the levels of user involvement and system support in accomplishing each type of search tactic. Three groups of search tactics were identified based on the significance of the *t*-test results and the associated means for the system support and user involvement. User-dominated search tactics were identified if the mean difference was significant and the associated mean for user involvement was higher than that of system support. System-dominated search tactics were identified if the mean difference was significant and the mean for system support was higher than that of user involvement. Balanced search tactics were identified if the mean differ-

ence between user involvement and system support was not significant. The term “balanced” is used to represent those search tactics that are neither dominated by users nor dominated by systems. Unlike user-dominated and system-dominated tactics, both users and systems have to play a critical role in applying these tactics. This implies that both users and systems have to collaborate more closely together to accomplish balanced search tactics.

This study builds on the 10 search tactics suggested by Xie (2008), and this paper reports the examination of 8 of the 10 tactics. Selecting databases was removed because it does not apply to all four types of IR systems. As to Keeping records, there was insufficient information gathered on this specific tactic compared with other tactics to merit its consideration.

Qualitatively, the open coding technique was adopted to analyze the qualitative data, in particular the types of user involvement and system support, as well as what users like, dislike, and desire system support for each type of tactic. Open coding is the process of breaking down, examining, comparing, conceptualizing, and categorizing (Strauss & Corbin, 1990). Table 4 presents an example of the coding scheme of the qualitative analysis. For each type of user-dominated, system-dominated, and balanced tactic, this table provides definitions and examples of types of user involvement and system support. To ensure intercoder reliability, two researchers analyzed the data independently, and discussed and made an agreement if disagreement arose. In order to avoid repetition and save space, more examples of user involvement and system support for each type of search tactic are reported and discussed in the Results section.

Results

Types of Search Tactics

The study investigated different types of search tactics that users apply in the IR process. For each type of search tactic, participants of this study required different types of user involvement and associated types of system support. To examine these differences statistically, we compared the participants’ perceived involvement and system support scales based on *t*-tests. Of eight types of search tactics, six of them were deemed significant at the alpha level of 0.05. Among them, participants perceived their levels of involvement were higher than system support in applying the following search tactics: Creating, Exploring, and Evaluating. These tactics are considered user-dominated search tactics. On the

TABLE 4. Coding scheme of qualitative analysis.

Tactic type	User involvement type	Definition of user involvement	System support type	Definition of system support	Examples of system support and user involvement
Evaluating	Assess the degree of relevancy of search results	Make judgment about the relevance of retrieved items	Relevancy ranking bar	System provides an indicator of relevance in displaying results	“EBSCOhost has a <i>relevancy ranking bar</i> across the bottom of each returned result. . . .The visual helps me establish just what degree of relevancy they are receiving, as does the commonly used percentage (of relevancy) often included with search results. . . .My first attempts did not bring back many relevant articles and the visual just made me more aware that I needed to re-formulate my query to do better.” (P28)
Monitoring	Keep track of previous searches	Decide when and what type of monitoring features to select	Search history feature	System provides records of previous queries	“EbscoHost wins hands down for monitoring search process or status. I loved it that I could at any time look at the plethora of searches I’d done by clicking on the Search History/ Alerts link at the top of the page.” (P22)
Learning	Understand instruction of help	Make sense of the meaning of the help to solve a specific problem	Search examples, visual illustrations	Provide easy-to-understand help information	“I appreciate a casual dialogue including search examples and visual illustrations in presenting help information, because it makes the information (which can easily become technology-term heavy) easier to understand for average users like me.” (P15)

contrary, they perceived their levels of system support were higher than user involvement in applying three other types of search tactics, including Monitoring, Organizing, and Accessing. These tactics are considered system-dominated search tactics. When applying Modifying and Learning search tactics, their perceptions of system support and user involvement did not have significant differences. Modifying and Learning search tactics are labeled balanced search tactics. Table 5 summaries *t*-test results of system support and user involvement in applying search tactics.

For user-dominated tactics, the *t*-test results showed that there was a significant difference in the perceived levels of system support ($M = 4.31, SD = 1.65$) and user involvement ($M = 5.98, SD = 0.99$) in applying Creating tactics; $t(120) = -6.788, p = .000$. This indicates that the participants perceived a higher level of user involvement than system support in applying query formulation search tactics. There was also a significant difference in the perceived levels of system support ($M = 4.82, SD = 1.63$) and user involvement ($M = 5.49, SD = 1.21$) in applying Exploring tactics; $t(120) = -2.570, p = .011$. This indicates that the participants perceived a higher level of user involvement than system support in applying Exploring search tactics. Moreover,

there was a significant difference in the perceived levels of system support ($M = 4.35, SD = 1.70$) and user involvement ($M = 6.26, SD = 1.04$) in applying Evaluating tactics; $t(119) = -7.445, p = .000$. This indicates that the participants perceived a higher level of user involvement than system support in applying evaluating search tactics.

For system-dominated tactics, the *t*-test results showed that there was a significant difference in the perceived levels of system support ($M = 5.18, SD = 1.67$) and user involvement ($M = 4.46, SD = 1.57$) in applying Monitoring tactics; $t(119) = 2.461, p = .018$. This indicates that the participants perceived a higher level of system support than user involvement in applying Monitoring search tactics. There was also a significant difference in the perceived levels of system support ($M = 5.81, SD = 1.34$) and user involvement ($M = 4.55, SD = 1.47$) in applying Organizing tactics; $t(120) = 4.929, p = .000$. This indicates that the participants perceived a higher level of system support than user involvement in applying Organizing search tactics. Finally, there was a significant difference in the perceived levels of system support ($M = 5.66, SD = 1.69$) and user involvement ($M = 4.37, SD = 1.70$) in applying Accessing tactics; $t(116) = 4.117, p = .000$. This indicates that the participants

TABLE 5. Categories of search tactics.

Category	Search tactic	Type	N	Mean (SD)	t (df); p-value	
User-dominated search tactics	Creating	System support	61	4.31 (1.65)	-6.788 (df = 120)	
		User involvement	61	5.98 (0.99)	p = .000	
	Exploring	System support	61	4.82 (1.63)	-2.570 (df = 120)	
		User involvement	61	5.49 (1.21)	p = .011	
	Evaluating	System support	60	4.35 (1.70)	-7.445 (df = 119)	
		User involvement	61	6.26 (1.04)	p = .000	
System-dominated search tactics	Monitoring	System support	61	5.18 (1.67)	2.461 (df = 119)	
		User involvement	60	4.46 (1.57)	p = .018	
	Organizing	System support	61	5.81 (1.34)	4.929 (df = 120)	
		User involvement	61	4.55 (1.47)	p = .000	
	Accessing	System support	59	5.66 (1.69)	4.117 (df = 116)	
		User involvement	59	4.37 (1.70)	p = .000	
	Balanced search tactics	Modifying	System support	61	5.32 (1.17)	-.326 (df = 119)
			User involvement	60	5.40 (1.25)	p = .745
Learning		System support	60	5.30 (1.58)	-.537 (df = 119)	
		User involvement	61	5.44 (1.32)	p = .592	

perceived a higher level of system support than user involvement in applying Accessing tactics.

For balanced tactics, the *t*-test results showed that there was no statistically significant difference in the perceived levels of system support ($M = 5.32$, $SD = 1.17$) and user involvement ($M = 5.40$, $SD = 1.25$) in applying Modifying tactics; $t(119) = -0.326$, $p = .745$. There was also no statistically significant difference in the perceived levels of system support ($M = 5.30$, $SD = 1.58$) and user involvement ($M = 5.44$, $SD = 1.32$) in applying Learning tactics; $t(119) = -0.537$, $p = .592$. This implies that users and systems have to collaborate more equally to accomplish Modifying and Learning tactics.

User-Dominated Search Tactics: Overview

Participants had to make intellectual decisions by applying their domain, system, and IR knowledge and skills to the Creating, Exploring, and Evaluating tactics. Nineteen types of user involvements were identified for user-dominated search tactics. Among them, making judgments and converting information needs into search statements were determined to be the most important ones. Moreover, participants had to make judgments about a particular document in applying

Evaluating tactics. In order to apply Creating tactics, participants had to convert their needs to search statements consisting of a different combination of terms. Understanding is the key for Exploring tactics, including understanding the relationships of items and labels of all the links. In applying these search tactics, participants preferred to take a leading role.

In applying these tactics, systems played an assistive role. Participants desired system support to extend their knowledge and skills and to facilitate applying these search tactics. At the same time, system support was also needed to highlight and present more required information for participants to make judgments. In addition, participants expected IR systems to help them efficiently accomplish these user-dominated tactics. Interestingly, participants disliked system support to take over their own roles in applying user-dominated search tactics; instead, they wanted to have more control in applying these tactics, in particular when they evaluated search results. In order to better present the results, quotes from diary data were used to illustrate the data. Because of the space limitation, the quotes chosen are typical, representative comments from the participants indicative of overall responses. The following Figures represent types of user involvement and associated types of system support based on open coding of diary data.

Creating

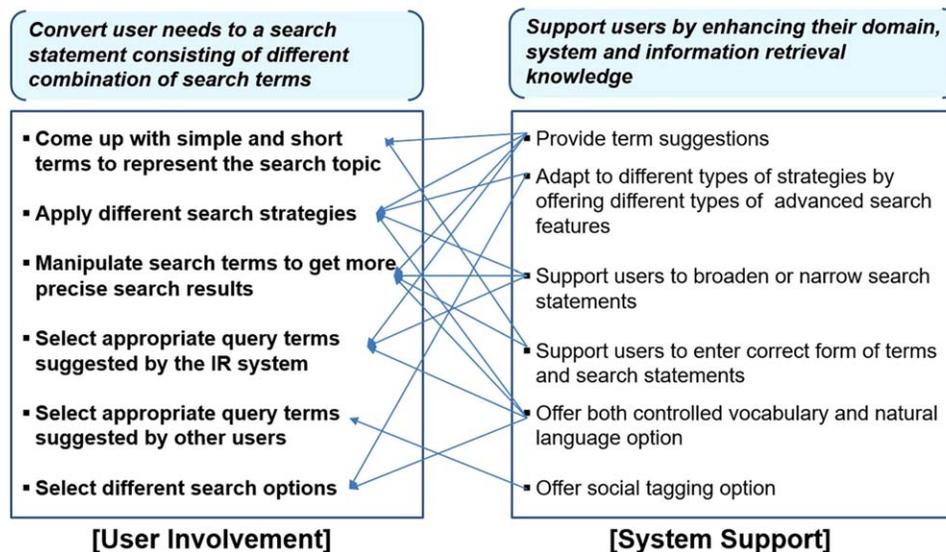


FIG. 1. Creating. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

User-Dominated Search Tactics: Creating

Figure 1 illustrates the types of user involvement and associated types of system support in achieving Creating tactics. Participants had to convert their information needs into search statements consisting of different combinations of terms. Creating a search statement is generally a user role, but systems can support the user by assisting the process of converting information needs into search terms. Ideally, participants expected that IR systems could adapt to different types of users. Participant 62 proposed, “I would like to see a system interface that offers search formulation features that change depending on the type of user, sort of like a ‘choose your own adventure’ start page to indicate to the system whether the user seeks to perform a complex search or just a simple search. Or a different strategy, after a basic search is submitted, the system could ask users how much information or of what quality they are looking.” Searchers also needed to manipulate the system features to apply different types of search strategies. For example, Participant 11 said, “The best of the four systems offering assistance with formulating search statements is Wilson’s OmniFile Full Text, which has Boolean operators, field searches, smart search, date and full text limiters, subject area and document type.”

Not all IR systems did a good job. Google Scholar was criticized for not offering enough options for users to create a specific search statement. Just as Participant 18 said, “The search feature that I disliked was advance search from Google Scholar. I did not like using the advance search because it did not give enough options to choose from. I couldn’t limit my search to full-text or limit the language.” Another problem is “all four IR systems should have a more visible link to search options and tools,” pointed out Participant 19.

Because of limitations of their domain knowledge, participants needed more sophisticated and supportive assistance

to choose query terms. Query suggestion is one of the most widely used features that an IR system offers to help users select more adequate search terms. For example, “. . .when I start typing a search term into the Google search bar, Google offers a list of suggestions underneath for me to choose from (P11).” Like this example, the participant did not need to type all the terms. That is, query suggestion made it easy for query creation as well as the identification of relevance (specificity) of terms. Similarly, controlled vocabulary provides another type of query suggestion: “Not only does EBSCO offer a thesaurus, but it also facilitates the building of the search statement from the thesaurus terms (P49).” Some participants expected both controlled vocabulary and natural language options offered from IR systems, as Participant 4 put it, “When formulating search statements, I would like the IR system to provide a list of controlled vocabulary search terms, yet still allow for natural language.” Recently, social tags have offered a new way of supporting users creating queries. In particular, a tag cloud was used as a good source for users to enhance their domain knowledge: “There is also a tag cloud that takes one to the tagged term in the book (P4).”

Spelling correction was also deemed an important system assistance in IR system design. In query creation, users tried to enter accurate and complete query terms, and the system was able to support them by correcting misspelled words. Participant 18 said, “. . .the search engine Google corrects misspelled words by showing possible results and then showing the correct spelling of the word followed by did you mean?” Interestingly, while many participants loved the spelling correction feature, some of them disliked it. Participant 52 stated, “When a search for Chief Seilu was performed, the system stated that ‘No pages were found containing Seilu.’” It did give me a few suggestions to retry and check my spelling or try different keywords. This is not

Exploring

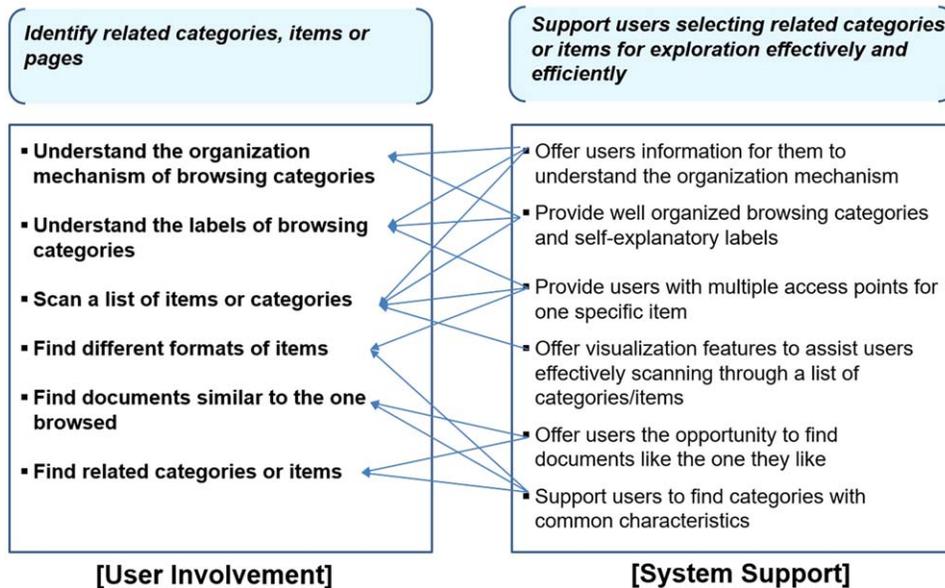


FIG. 2. Exploring. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

necessarily helpful when you may think you have it correctly.”

User-Dominated Search Tactics: Exploring

Figure 2 illustrates the types of user involvement and associated types of system support expressed in achieving Exploring tactics. Exploring refers to browsing information/items at a specific site. Basically, participants engaged in Exploring tactics by identifying related categories, items, or pages while the system provided them a list of related items. In order to select a category or item, participants had to scan a list of items when applying Exploring tactics. IR systems needed to support their scanning behaviors by offering different types of browsing options. Those categories or item lists could be related to similar items, citing or cited items, among others.

Participants preferred well-organized browsing categories to help them select the right category to explore. It is vital for participants to understand the organization of a browsing mechanism, and organizing by subject was the preferred way for participants to explore information. Here is one typical quote, “When exploring information I would like the IR system to organize the topics into headings or subcategories. Once I click on that topic, it breaks into subcategories (P53).”

Moreover, multiple options in organizing browsing categories were preferred. “The system presents clearly labeled categories from which to choose, such as by subject/topic, format (maps, images, etc.), time period, or location,” stated Participant 34. In addition, different view options were deemed helpful in scanning through the list of categories/items. Some systems provided users with choices to view

the selected items, such as gallery views, brief views, or full views. Participant 54 explained, “I also think the gallery view in American Memory is fun to use since some pictures may spark a latent interest.” The self-explanatory labels of the browsing categories facilitated users to clearly understand the labels of categories or items as described in the following quote, “All the navigation is well marked with self-explanatory vocabulary (P44).”

In exploration, another challenge for participants was how to find documents similar to the one that they liked. In the study, participants liked the following support from IR systems: i) offering a list of related items directly. Participant 11 liked that “Amazon offers similar products to what I’m looking for”; ii) offering a list of items indirectly. “For research, Google Scholar’s ‘Cited in’ function can be helpful for finding other sources,” praised Participant 3. It seems that participants preferred the way they usually surveyed the libraries when they explored digital libraries. Participant 8 described her favorite browsing systems, “Perhaps it could be a touchscreen wall of the library that would include a map of all shelves in the entire library.”

While participants liked to make their own decisions during exploration, there was a limit to how many decisions they had to make. Participant 49 complained, “Clicking on the title/descriptor for various collections leads to a list of limiting questions. I was asked three times to limit my search. When I browse, I don’t want to make that many decisions.” At the same time, participants did not want to get lost in the exploration process. As Participant 2 put it, “My least favorite IR support feature for exploring is that offered by EBSCOhost. It is easy to get lost in the layers of information without having a clear way back to the beginning of the search.”

Evaluating

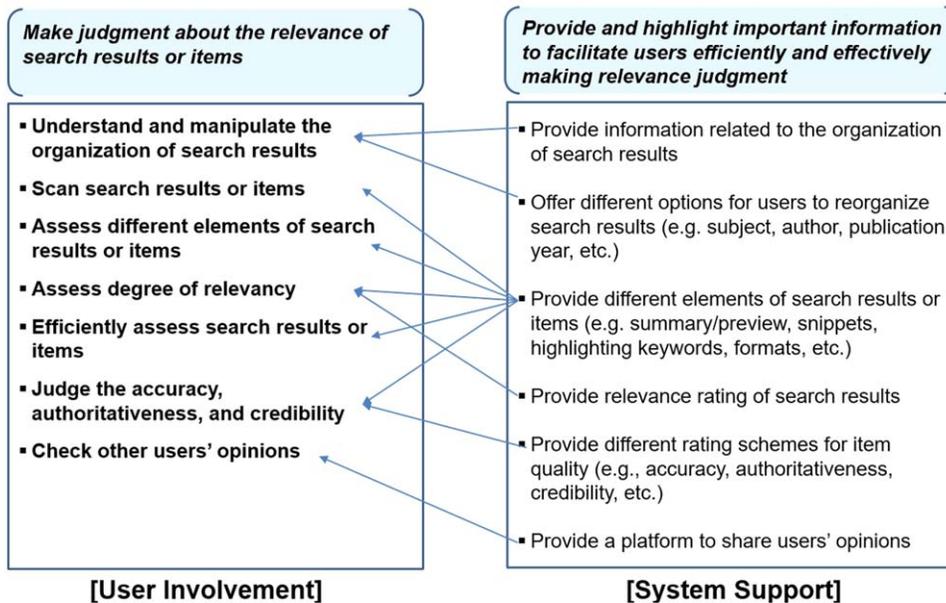


FIG. 3. Evaluating. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

User-Dominated Search Tactics: Evaluating

Figure 3 illustrates the types of user involvement and associated types of system support in achieving Evaluating tactics. User involvement is first reflected in that participants needed to know the mechanism behind the organization of the search results. They also liked to have the freedom to manipulate the organization of the results, which could help them make decisions in selecting relevant items. As Participant 53 complained, “For the IR system that I dislike the most in terms of organization is American Memory or Google. American Memory organizes in terms of relevance but was not clear to me at first of how it might be relevant without further exploration. Likewise, Google organizes items by relevance but does not give the user a chance to choose if they would like the items organized by subject, keyword, etc.”

In scanning a list of search results and then determining the relevant items, participants were likely to scan the top-ranked results even though they did not completely understand or trust the relevance ranking, and they expected IR systems to support their scanning of search results by offering related information to assist them to judge the relevance of documents. Some participants considered a display of numerated measures that indicated relevance to be useful. As Participant 43 put it: “One feature I liked very much was EBSCOhost’s relevancy meter that is used on every result to show how relevant the result was to the query.”

Participants needed to not only select items from the search list, but also make relevance judgment on each individual item. For that reason, they relied on different system features to help them quickly capture the information they needed. The presence of a summary or information snippet for each item was the key: “The system that makes it easiest to evaluate a record is actually Google because it contains

excerpts from the actual resource (P62).” Previewing features, such as a pop-up box and magnifying glass, were favored features by users to make a decision whether they needed to further read the item: “They [EBSCOhost] offer a magnifying glass icon next to each result that clicking on gives a more detailed view of the item with title, author, source, subject, and an abstract. I think it is important for a system to provide some kind of excerpt of the item retrieved in a search in order to help me quickly decide whether the item is the one I want to delve into further (P36).” Drawing more attention to key concepts was useful, as Participant 38 explained, “Clusty’s option to highlight the topic headings and subheadings is unique and useful.” Highlighting the query terms is also critical for participants to make effective judgments. Participant 29 put it well, “EBSCOhost boldfaces each occurrence of the query words in the abstract. This is very useful in determining whether the article is worth obtaining.”

Information regarding format of an item was also central for participants to make relevance judgment of a multimedia item. Participant 24 specified the benefits of showing a picture of a resource, “The digital collection showed pictures with a description of each resource so the user knows exactly what type of resource they will be looking at.” “If the IR system retrieves sound information, the results would include an icon where the user could easily click and hear a sample of the sound,” recommended Participant 2. Of course, it was considered more beneficial if other types of information could be provided. “The AADL catalog offers the best evaluation features. I am able to see important details for each item, such as a thumbnail image of the cover, title, author, publisher, call number, availability, and what type of item it is,” stated Participant 62.

Monitoring

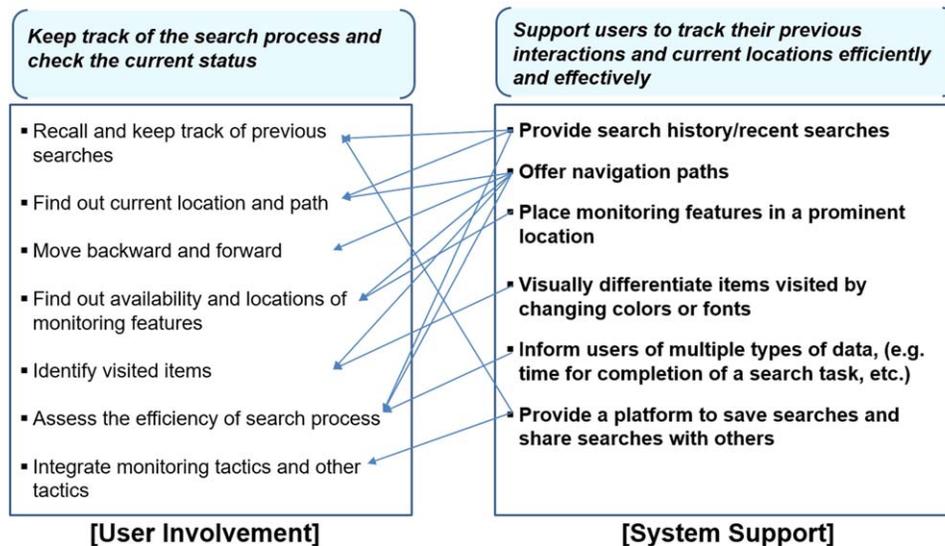


FIG. 4. Monitoring. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

In addition to relevance of items, many of the participants trusted themselves more than IR systems. They liked to go through the results and selected what they really believed. They spent more effort in evaluation than creating search statements. They needed IR systems to facilitate them judging the accuracy and authoritativeness of a document instead of judging for them. For instance, Participant 9 said, “The IR system should not have to tell me whether or not a particular resource is reliable, but rather give me enough information to judge for myself its accuracy.”

Participants also preferred to make judgments about the credibility of a document, although they relied on the IR systems to help make their decisions. They trusted peer-reviewed and scholarly journals and expected IR systems to offer filters based on the peer-review status for better decision making. Online databases, which offered this feature, were praised, “EBSCOhost has created filters that encourage me to trust the site understanding the results I view are peer-reviewed and scholarly (P10).” Some participants preferred the way Google displays URLs so they can quickly choose more credible sources. Participant 1 explained it well, “I especially like how Google displays URLs on the search page. This makes it easier to select sites that appear to be reliable and to bypass those sites that either appear unhelpful or even harmful to computers.”

Interestingly, some participants also took account of other users’ comments for their decisions on the usefulness of an item. Participants wished that IR systems would provide a platform to share users’ opinions or comments about a certain item. Participant 4 commented on the user reviewing and rating feature of WorldCat, “The feature that I like the most for evaluating search results is the Reader Reviews section of the result page in WorldCat, especially for books.”

System-Dominated Search Tactics: Overview

System-dominated search tactics encompass Monitoring, Organizing, and Accessing tactics. Systems play a major role, while users only need to initiate these tactics. While participants decided when and what to monitor, organize, and access, they expected system support to execute the commands for them. Participants liked system support to offer multiple options to facilitate the accomplishment of these tactics. Of course, efficiency is another goal; IR systems need to design features that can assist users to quickly monitor, organize, and access. Participants appreciated more ease-of-use features in applying system-dominated tactics.

System-Dominated Search Tactics: Monitoring

Figure 4 illustrates the types of user involvement and associated types of system support when engaging in Monitoring tactics. Participants decided when, what, and how to keep track of their searches. At the same time, they needed IR systems to assist them to effectively track their previous interactions. The results show that Monitoring tactics were mostly accomplished by using search history or a similar system feature. When participants wanted to recall what they searched before, they simply checked the search history. Here is a typical quote from Participant 19, “EBSCOhost’s ‘Search History’ tool is ideal, and clearly visible from the main page, and from the results page.” More important, participants expected the monitoring features to not only show their search history and path, but also guide them in reformulating their queries. Participant 16 stressed, “In monitoring search process and status, the results page should help me keep track of my search parameters and environment, and help me tweak my search easily.”

Organizing

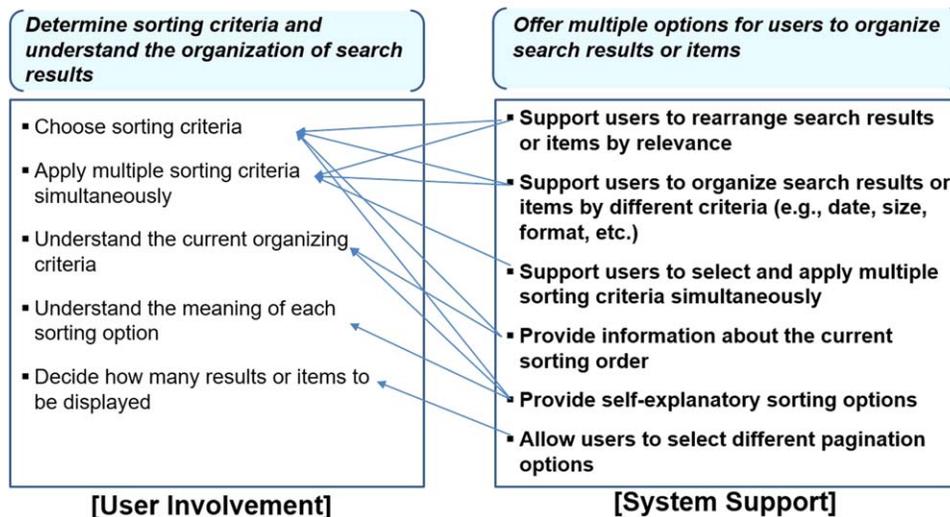


FIG. 5. Organizing. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

At the same time, participants were disappointed that not all IR systems had monitoring features available, particularly in digital libraries. Participant 46 pointed out, “The National Science Digital Library does not have a way for me to view search history or to return to previous search screens. This makes it difficult for me to return to other search results I find helpful or to return to the original search after I’ve modified the results.”

In addition to keeping track of previous interactions, participants also needed to check their current status and their paths, for example, where they were, how did they get here, etc. This was explained rather well by Participant 1, “I find American Memory facilitates exploration very well. Clicking on a subject leads to a number of collections within that subject, and clicking on a collection leads to information about the collection, along with items in it. The path shows on the top of the page.” However, not all IR systems have the same design of monitoring functions. At the same time, many participants complained about the lack of monitoring functions to specify their paths in IR systems, for example, “I want an IR system to monitor my path for me, and display it where I can easily refer to it, and use each stage of the hierarchy as hyperlinks so I can use them to navigate backwards and forwards (P32).”

It was not sufficient for participants to only monitor search queries and paths. They also preferred tracking information consisting of multiple types of data. Among them, time is an important aspect, as Participant 55 pointed out, “Both Google and WorldCat note the time a search takes. This information can be helpful in gauging the complexity of a search, which can provide insight into search statement revision.”

Also, participants appreciated that some IR systems offer the opportunity for them to integrate Monitoring tactics with their individual folders in the system and further share infor-

mation with others. Participant 24 stated, “Desired features when monitoring a search process or search status would be the ability to save search history with results and the ability to share them with other users.” The tradeoff is most systems that supported Monitoring tactics required individual accounts or cookies to identify users. As one participant explained, “In order to keep track of my research, I need the system to track the search and provide an (individual) account that will save searches upon request (P49).”

System-Dominated Search Tactics: Organizing

Figure 5 illustrates the types of user involvement and associated types of system support in achieving Organizing tactics. Participants first wanted to determine sorting criteria for search results, and they expected IR systems to offer multiple options for sorting. Choosing a sorting criterion to rearrange the search results is the first step for search result organization. Most IR systems offered sorting criteria by relevance, date, author, format, and others. For example, “WorldCat allows you to sort results by relevance, author, title, and date (older first or newer first),” specified Participant 43. While most of the online databases and OPACs offer sorting options, many of the web search engines and digital libraries do not. Here is a typical complaint from participants, “I disliked American Memory and Google because you are not able to organize results in a manner that makes sense for your search or helps to locate the most important information within your results (P58).”

Of course, participants were not satisfied with sorting the results by one criterion; instead, they preferred the ability to apply multiple sorting criteria to more efficiently identify relevant results. Participant 34 explained, “My desired sorting feature would be the one that would allow me to select more factors to sort by, rather than restricting to one aspect

Accessing

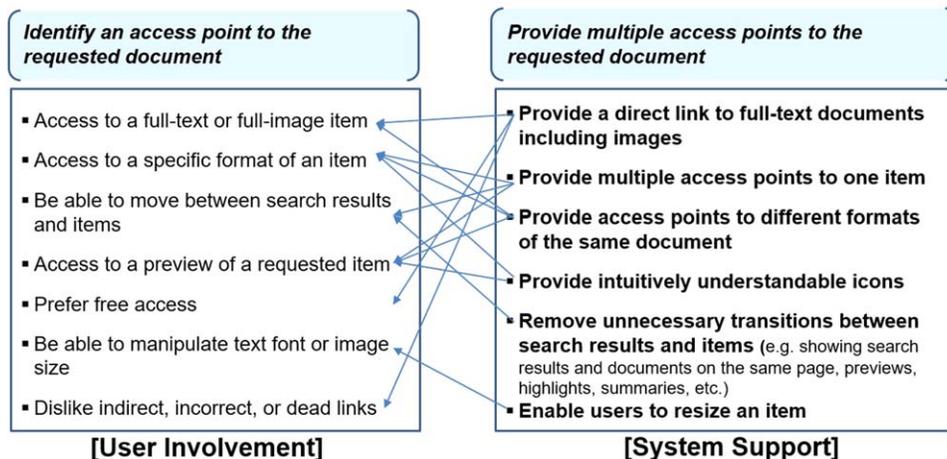


FIG. 6. Accessing. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

at a time, where applicable.” Participant 18 proposed one unique sorting function, “One desired feature that I wish the retrieval system had would be the feature to rank the most relevant articles first and rank them according to how many times those articles were cited in other scholarly works.”

More important, participants sought an explanation of how the search results were organized so they could choose the right sorting criterion. Participant 28 complained, “The system features I found least helpful in organizing search results were the ones on the mndigital.org site. It allowed you to sort by ‘image,’ ‘title,’ ‘subject,’ or ‘description,’ but clicking each heading and having it re-sort did nothing to clarify what kind of organization it was re-organizing into. I could not find any clear explanation or pattern for how this was supposed to be helping me, so it was not useful.”

Participants also preferred to have the freedom to define pagination as part of the sorting option. Many IR systems allow users to set the number of search results in a page: “Wilson Web comes closest to what I want. By default, they order the results in order of relevance using percentages. I am also given the option to sort by date, author, publication, and so on. I can list 10, 20, or 50 results per page (P47).” In addition, participants liked to view search results sorted by different criteria at the same time. “. . . it would also be great if the system could display several columns of the same results sorted by different selected criteria,” Participant 34 expressed her desired display option. Participant 62 described her ultimate interface, “My ideal IR system would provide an interactive, visual, and flexible interface that recognizes semantics. Results would be presented within categories, possibly using collapsible menus in order to save space and keep the page clutter to a minimum.”

System-Dominated Search Tactics: Accessing

Figure 6 illustrates the types of user involvement and associated types of system support in achieving Accessing tactics. A participant’s main responsibility was to identify an

access point to the requested document. The diary data showed that participants wanted direct access to full-text documents, and they looked for direct links to those full-text documents. For example, “I quite liked the Public Library of Science (PLOS) digital library, as a single click on the retrieved link would provide access to the open access article,” Participant 59 said. Easy access is the key for users; however, participants had differing perceptions about easy access. Participant 2 offered a general picture of easy access, “An ideal IR system clearly displays all possible ways the user can access the information and provides a clear, easy path to obtaining the information.” To some participants, easy access refers to easily navigating between the result list and documents in the list. “I would like to see a system that allowed accession of individual results while still maintaining a small version of the results list in the corner of the page in order to refer and easily navigate between results,” said Participant 2. Some participants preferred easy navigation from the item’s metadata to the item and result list. Participant 50 expressed it well, “I think systems should account for my need to move quickly between an item and the search results—it should be simple to move from the metadata to the item, and back to the search results.”

Participants appreciated easy access and preferred IR systems providing clear information or icons for search results and document accessing. However, some icons presented by IR systems were confusing. “Although WorldCat has a book cover preview, it does not always show them. Many of them in my search were blank squares. It also does not offer a large amount of information before you go into the item,” Participant 52 complained. Participant 32 expressed her vision of an ideal icon design, “My ideal accession feature in an IR would be to have icons throughout the results pages, such as a video recorder for a DVD, book, etc., so that I would just need to click on that icon and either be taken to that page or be given information on the location of the item.”

Participants also expressed a need for direct access, and they disliked indirect links, incorrect links, and dead links.

Here are some examples of situations in which participants complained about the problematic links. “The feature I disliked the most was accessing the incorrect information from the Internet Public Library (P18).” “The dead links in Google is the least desirable aspect of accessing text documents, images, or streaming videos (P16).”

Participants engaged in the selection of different formats of an item and preferred multiple access points to the item. For example, some online databases provided both HTML and PDF versions of an article, and enabled participants to select their preferred format to access the item. Participant 4 praised multiple access points offered by an online database, “I like EBSCOhost’s feature of allowing access to an article via html or PDF. With immediate access to an article, I can determine if the article is relevant and save or print it for future use if it is.” Visual icons led participants to intuitively access the format they wanted: “Gale Academic OneFile did a tremendous job of prominently displaying an Adobe .PDF icon whenever there was an item available in PDF format (P11).” In order to access multimedia documents, participants needed to know how to view or play them. However, not all IR systems provide the information about how to access. Participant 62 identified the problem, “Ideally, a system would have built-in media players and image and file viewers, and include clear directions or design cues to show the user how to access items. This would then allow me to install these types of programs to access the content.”

Sometimes participants were interested in accessing previews or highlights instead of full documents. In that way, they could quickly grasp the information without the effort to load the full document: “Clusty offers three icons next to each record on the results page to open, preview or highlight the appropriate record (P38).” Accessing was also related to accessing content in documents. Participants preferred to zoom in documents and disliked some IR systems that do not provide that option: “I was most disappointed by American Memory’s access to written documents. When I was looking at some of Lincoln’s letter, I could not view the larger image along with the transcription. I was also not able to zoom in on a particular word that I might have trouble reading. (P4)”

Balanced Search Tactics: Overview

In applying the balanced tactics of Modifying and Learning, both participants and systems had to collaborate together. To be more specific, participants and systems needed to interact more closely in order to apply these tactics. Before participants reformulated their search statements using the Modifying tactic, they liked to review search results generated from systems to decide whether to broaden up, narrow down, or come up with search statements that parallel with the previous search statement. At the same time, system support should also interact with participants by suggesting potential terms and documents. The same phenomenon applies when pursuing Learning tactics. Participants needed to identify the problems and select appropriate help features,

and systems needed to provide understandable explicit and implicit help features in order to solve these problems.

Balanced Search Tactics: Modifying

Figure 7 illustrates the types of user involvement and associated types of system support in achieving Modifying tactics. When creating the original search statements, the participants’ role was more important. However, when modifying the initial query terms, they required increased system support. Thus, Modifying tactics were classified as balanced search tactics that require both users and systems to work together. Participants engaged in Modifying tactics by reformulating search statements while systems provided multiple reformulations options. Most user involvement and system support in query modification overlapped with those exhibited in the cases of Creating in this study. Thus, unique types of participant involvement and system support for Modifying tactics, distinct from Creating tactics, are emphasized here.

The most support for applying Modifying tactics that participants required was to enhance their domain knowledge by adequately selecting narrow terms, broad terms, or synonyms that IR systems suggested. “In WorldCat and EBSCOhost, the related search terms come to me after the initial search is completed; the system then shows other terms so that the search can be refined further,” described Participant 14. Also, some online databases suggested broad or narrow terms or synonyms based on the participant’s initial terms. These features eased their intellectual effort for reformulating their queries: “The list of terms to the left side of the screen that appears after performing the initial search is very helpful if I need to broaden or narrow my search,” commented Participant 4.

In addition to domain knowledge, participants also had to enhance their information retrieval knowledge. Participants needed the IR systems to make the connection between natural language and controlled vocabularies. “I think a feature that would be helpful for reformulating search statements would be system feedback regarding controlled vocabulary. If the system could recognize close matches between natural language terms and controlled vocabulary, this could be useful for searchers,” specified Participant 50.

Multiple approaches to refining the search results made it easy for participants to apply Modifying tactics. Participant 51 expressed it well, “Worldcat’s left hand ‘refine your search’ menu allows you to select format types, search by year published, author, and content among others. These types of tools help users explore and find information in different ways.” Participant 8 said, “I think EBSCOhost does the best job in allowing me to reformulate my search because it has such a wide variety of limiter options.” Simultaneously, it posed a problem if an IR system did not offer this type of option. “I had a hard time reformulating a search in American Memory only because there is not an advanced option. I can only choose to try browsing by a different

Modifying

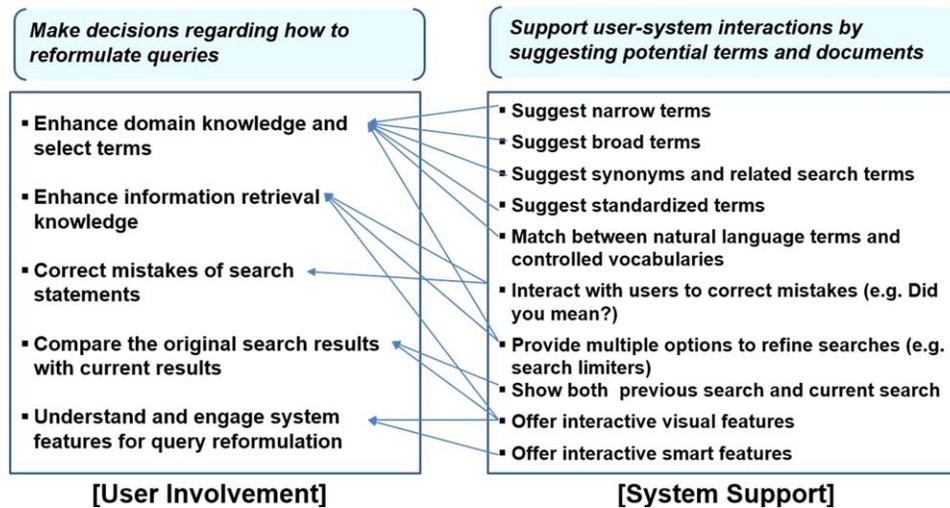


FIG. 7. Modifying. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

collection to see if they can get better results," Participant 7 complained.

One unique participant involvement when modifying search statements was that participants would like to compare the original search results with current search results during reformulation. Participant 18 described the desired feature, "A desired feature that I would like to have is the option to split the screen and show the previous search while performing the new reformulated search. I think this feature would allow me to see the differences on the same screen between results."

Interaction in an unobtrusive method is more appreciated by the participants. "I'm most fond of WorldCat's system, especially where hovering the cursor over a classification number gives the relevant subject heading," stated Participant 44. When participants made a mistake, they preferred the system to interact with them to clarify what they really mean in the query reformulation process. Many participants praised the "Did you mean?" feature in multiple IR systems: "EBSCOhost might be the best because it typically offers more suggestions such as 'Did you mean?' (P45)"

For effective interactions, new visual and smart features are offered by different IR systems. "The visual search in EBSCOhost displays related terms and shared subject terms. Reformulating a search using one of the listed subject terms can create a more useful result list," explained Participant 21. Although participants enjoyed the benefits of using these features, they did not want to be excluded from the reformulation process. Participant 46 complained, "When a search statement did not retrieve results, the system relied on a feature called SmartText search. Though I enjoyed the feature in terms of the results, I was no longer involved in the process."

Balanced Search Tactics: Learning

Figure 8 illustrates the relationships between types of user involvement and associated types of system support in

achieving Learning tactics. In general, Learning tactics can be achieved by trial-and-error, but that is not efficient. A user can better apply Learning tactics by making good use of system help features. In this study, participant involvement focused on identifying their problems, locating and comprehending related help features, while system support was needed to offer different types of explicit and implicit help features.

In order for participants to effectively apply Learning tactics, it required participants and systems to interact seamlessly with each other. Participants tried to learn how to search effectively in an IR system from the explicit help features provided by the system. Participants liked to read clear instruction with examples to solve a problem. Participant 62 specified the importance of including examples in help features, "The IR system with the best learning and help features is the American Mosaic database. Not only are there multiple types of guides addressing the various areas of the database, but each question is clarified and described in detail, with suggestions and text and visual examples when appropriate."

Participants also recognized the helpfulness of implicit help. Implicit help is not labeled directly as a help function, but it supports users' system learning process tacitly while they go through the search process. Participant 2 suggested, "Since people don't readily use the help feature, I might call it something else. This might be a phrase like, 'I can't find it. What's my next step?'" For participants, intuitive design itself is considered as a good implicit help feature: "Google's basic search interface is a good example. I like it simply because I know how to use it. I don't want any other support: I believe that a system should be intuitive (P44)." "Search tips" are a typical type of implicit help that contains examples that participants really liked. Just as Participant 3 put it, "Project Gutenberg offers search tips on the advanced search page and links to 'How-to's'." FAQs were another

Learning

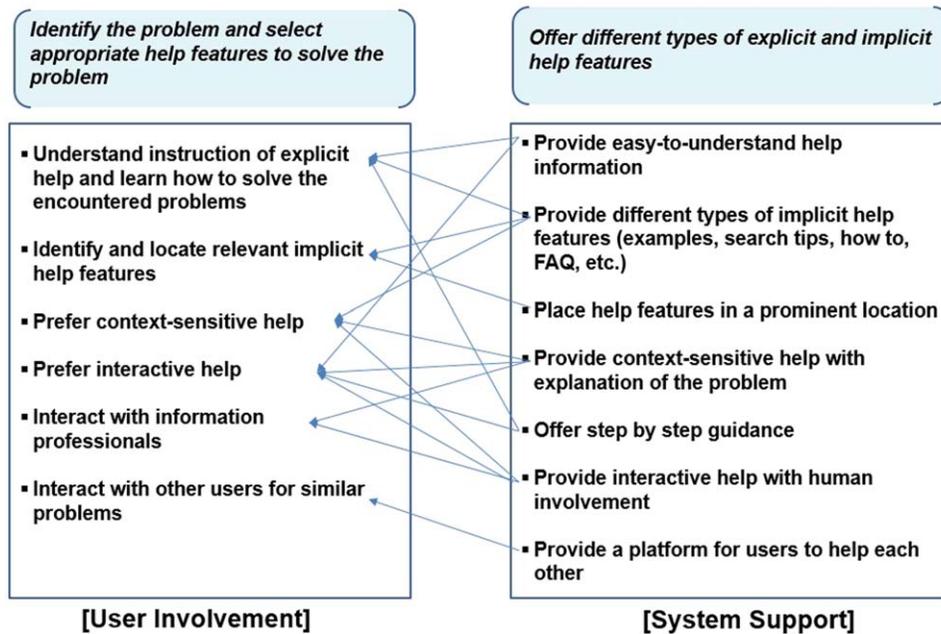


FIG. 8. Learning. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

type of frequently used implicit help. Participant 19 discussed what she liked about features to support Learning tactics. “American Memory has the best help feature for learning the system and searching. It also has a FAQ section and contact section, which includes ‘ask a librarian’ and error reporting.”

Many of the participants noted the importance of help feature accessibility. However, in some IR systems links to help pages were not easily accessible, as they are not located prominently on the page: “Locating the help tab wasn’t easy in all the IR systems (P43).” Participants also liked to have the help page and their search page integrated together. “Having the help open in a window that does not take you away from the search page and results is the most helpful feature of all, so I can simultaneously explore and learn from help while reformulating and evaluating my search and search results,” proposed Participant 15. At the same time, some participants preferred to have a separate page for all the help features. “Having a separate menu page for all the different help features and allowing me to see them all at once would be useful,” Participant 9 suggested.

Context-sensitive help was a desired feature for participants to identify their problems and offer solutions. It was difficult for participants to look for the help they needed. Participants identified two typical problems of help, “The error messages in EBSCO are useless. It would not be difficult to embellish them to provide useful search tips or at least an explanation of why the search failed (P61).” “The search help page on the American Memory was ambiguous and if the direct question was not listed under FAQ’s, then one must attempt to browse more collections by ‘trial and error’ (P10).”

In order to understand how to accomplish some of their tasks, participants chose interactive tutorials that offered detailed and step-by-step guidance. Participant 4 explained well, “When learning how to work on an IR system, I would like an interactive tutorial that gives immediate feedback on what I am doing wrong and how to improve my search strategies.” In particular, participants loved systems to use screen shots to guide them through the steps, “The Help provides many screen shots to walk through the element I am exploring as well as a thorough list of help topics I can click on . . . it would provide plenty of screen shots and very clear step-by-step directions,” described Participant 32.

Participants preferred more interactive forms of system support with human involvement. In digital libraries or OPAC environments, many systems offered reference services through multiple channels, such as e-mail, online contact page, and Live Help, which is based on an online instant chatting framework. Participant 18 expressed what he liked, “One feature that I liked was live help. By live help . . . The IPL offers live access to a librarian that can help with a search.” Along with expert-user interaction helps, some participants utilized user-user help forums; participants tried to solve the problems they encountered by asking other users with similar experiences. In this case, IR systems helped them by offering a platform where they could help each other. Participant 4 said, “I liked that there is a forum where users post questions about problems they are having with the system, and other users are able to help resolve these issues.”

Of course, users are not all the same and not all help features are used by everyone. Participants thought Help features should be designed to enable them to easily control the

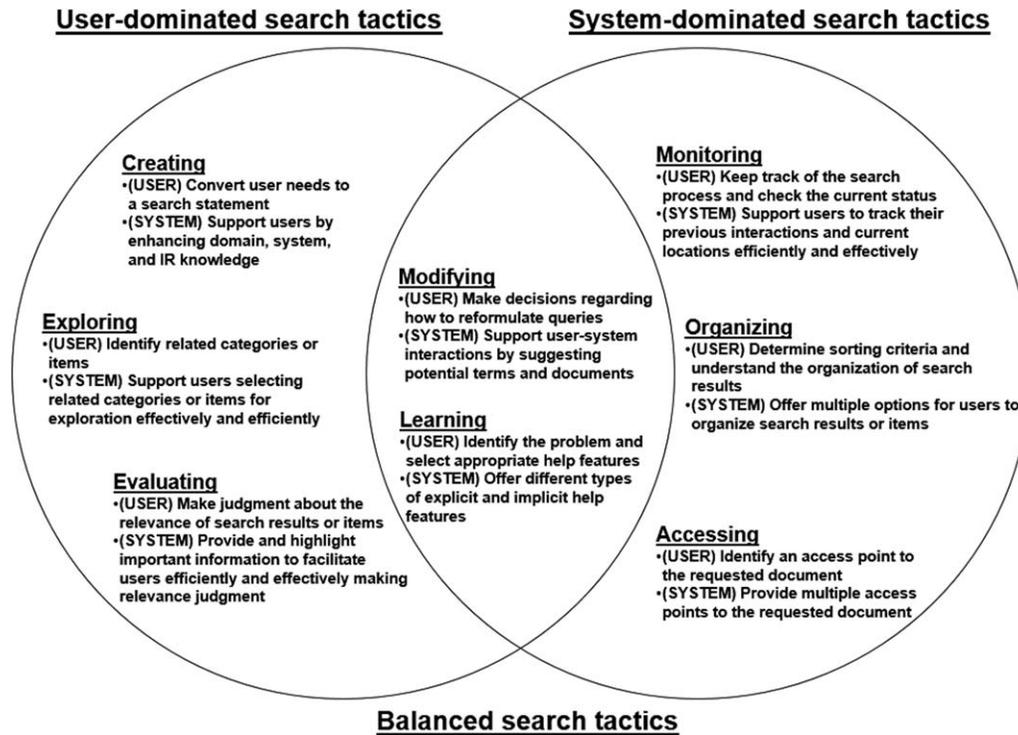


FIG. 9. Model of user involvement and system support.

help features. As Participant 26 commented, “It should be my choice of whether to turn on this feature or not. I should not have to go searching for how to turn on the feature. It could be designated as ‘turn on/off assistant feature.’ Bing gives the user the ability to turn on/off <search suggestions>, but the user has to go searching to find out how to do this.”

Discussion

Theoretical Implications

The study comprehensively examined the reciprocal relationships between user involvement and system support in the search process. Figure 9 presents the model of user involvement and system support in applying the key search tactics. The findings of this study validate previous research regarding interactions between users and systems (Bates, 1990; White & Ruthven, 2006; Xie, 2003; Yuan & Belkin, 2010). The unique contribution of this study can be highlighted in multiple ways. First, this study creates a new model in interactive IR that incorporates user involvement and system support into the IR process. While previous macro-level interactive IR models (Belkin, 1993; Ingwersen, 1996; Saracevic, 1997) primarily focused on the main IR constructs and their relationships in the interactive IR process, previous micro-level interactive IR models emphasized the key elements of the interactive IR process (Bates, 1989; Marchionini, 1995; Vakkari, 2001). Very few prior studies considered the types of user involvement and system support

in illustrating the search process. This study identified the types of search tactics in which users play a dominant role, types of tactics in which systems play a dominant role, and types of tactics in which users and systems must collaborate more closely together. The identification of these three types of tactics clearly shows that users and systems do not play the same role throughout the IR search process.

Second, this study specified the types of user involvement and types of system support needed in accomplishing search tactics. Users not only participate in the search process physically by manipulating system functions but also cognitively by making intellectual decisions. In applying user-dominated tactics, they use their knowledge structure to make their own intellectual decisions. At the same time, they expect IR systems to enhance and support their domain knowledge, system knowledge, and IR knowledge. In applying system-dominated tactics, while users decide when and what to do, systems take the leading role by offering various system features to enable users to execute their search tactics. In applying balanced tactics, users and systems interact with each other in order to fulfill the search tactics together. The specifications of user involvement and system support clearly portray the types of interactions that take place between the user and the IR system in the IR process.

Third, this study also reveals that not all users are the same. Users have different preferences in terms of what they prefer to perform themselves and what they want the systems to undertake for them. In applying user-dominated tactics, users exhibit different preferences in making decisions while applying search tactics. Some users preferred to act on

their own and use advanced features, while other users relied more on systems to guide them through the search process. This poses a challenge for IR systems to assess user preferences in diverse situations. In applying system-dominated tactics, users also exhibit different types of needs. While multiple system features were desired for users to support them to achieve specific types of search tactics, some of them didn't want to be forced to use these features. They preferred to understand what systems present or provide to them first, while others preferred just accepting whatever information or features the systems offered to them. In applying balanced tactics, users preferred interacting with diverse system features, such as visual features and text features. They also exhibited different interaction patterns, which were related to varying sequences of actions pursued in achieving these tactics.

IR System Design Implications

Based on the findings of the study, specific design implications are discussed for user-dominated, system-dominated, and balanced search tactics. In applying user-dominated search tactics, users engage in the search process in different ways by "performing" a range of activities, such as reading, comprehending, checking, manipulating, identifying, producing, selecting, determining, judging, and assessing. System roles need to extend the user's domain, system and information retrieval knowledge. A user's domain knowledge or topic familiarity can be enhanced by reading descriptions or best passages provided by the system. Selection, determination, and judgment are the user's intellectual responsibility based on the analysis of the obtained information from the system. In addition, users have different preferences in interacting with IR systems. Adaptive IR systems are essential to adapt to user preferences. By utilizing user profiles, search patterns, or previous query and page view histories, IR systems can infer user preference and knowledge (Cole, Gwizdka, Liu, Belkin, & Zhang, 2013; Lu, 2012; Ochoa et al., 2013).

For system-dominated search tactics, system features directly influence the search process. Searchers rely on system features to accomplish system-dominated search tactics. For Monitoring tactics, users rely on search history, recent searches, and visited pages provided by the system to recall and keep track of previous searches. The navigation path feature can be useful for users to find out their current location in the IR system. As for Organizing tactics, it is not easy for users to organize search results or items without sorting functions provided by the system. Therefore, the availability of various sorting options is a must in order to accomplish Organizing tactics. Credibility is a unique sorting criterion that users appreciate to organize their results. Moreover, it is important to present user-understandable sorting functions by providing self-explanatory labels and clearly showing the currently applied sorting criteria. System design for Accessing tactics should focus on direct access to the items returned by the search process. It is useful for IR

systems to offer users access to an item with multiple options (e.g., download, preview) and multiple formats. As users access from search results to individual documents, it is necessary to create an interface that shows search results and documents within a single page. Overall, IR systems need to reduce the amount of user effort required to perform system-dominated search tactics, and they should offer the most efficient process to complete a system-dominated tactic. For example, IR systems can remove all unnecessary paths for Accessing tactics or provide one-click solutions to enable users to use any applicable features for Monitoring or Organizing tactics.

System support for balanced search tactics should focus on facilitating user-system interactions. Basically, system features for Creating can be helpful for Modifying tactics, but applying Modifying tactics requires further system assistance to interact with users by supplying different query reformulation options and explanations. In addition to suggested related terms, IR systems should provide a built-in thesaurus for users to interact with an existing knowledge structure that supports the search process for better precision or recall. Different categories of search limiters are beneficial to users to narrow down their search statements. Spell check and correction is another valuable feature to assist the user with query reformulation. However, users need to have the option to turn spelling correction on or off. Additionally, splitting the screen to show both the previous and current results enables users to easily compare the original and new search results. Learning tactics also require input from both users and systems. Users sometimes cannot identify their problems, and IR systems need to provide context-sensitive help to aid them in identifying their problems and offer solutions. Error specification and explanation is one effective approach for users to understand and solve their problems. Synchronous live help can also be useful to produce contextual and customized assistance to users. In order to learn, users need to read and comprehend the instructions provided by IR systems. Therefore, it is important to make help information easily understandable and self-explanatory. In particular, help information can be provided in different formats, such as text, video, images, and examples with screenshots. Search tips, how-to's, and FAQs are popular ways to provide instant help to answer common problems encountered by users. Of course, when designing explicit and implicit help features, it is important to place them in prominent spots consistently for users to easily locate help information. Last but not least, creating user forums within an IR system is a desired feature for users to ask questions and share their experience in acquiring domain, system, and IR knowledge.

Conclusion

This paper presents the types of user involvement and associated types of system support needed when users apply user-dominated, system-dominated, and balanced tactics in the search process. The significance of this study is that the findings reveal that users and systems don't play equal roles

when applying different types of search tactics. The results indicate that users would like to play a major role in achieving user-dominated tactics, while they expect IR systems to play a modest role in extending their domain, system, and IR knowledge without overshadowing their own role in the process. When users apply system-dominated tactics, they prefer to delegate the realization of the tactics they initiate to the IR system. When users apply balanced tactics, users and systems need to closely interact with each other to collaboratively perform these tactics. For each type of tactic, specific design implications are generated based on the findings of the study.

This study also has its limitations. Participants of this study represent users in the academic setting who may not represent the general users of information searching. Since user knowledge has a major impact on user involvement and system support, it would be beneficial to collect data in relation to their knowledge levels, in particular domain knowledge. While diary data were collected in a natural setting, think-aloud and log analysis could be employed to offer richer data in the search process. The next steps for further research should endeavor to broaden the scope of user testing and also deepen the understanding of how other variables, such as domain knowledge, impact the roles of user involvement and system support. In future studies, templates of interfaces to support the three groups of tactics should be designed and tested. Moreover, future research should investigate how general users with diverse search tasks and different levels of knowledge interact with IR systems physically, cognitively, and effectively in applying search tactics. Further research also needs to design experimental studies to compare the nature of user-system interactions in applying user-dominated, system-dominated, and balanced tactics in the IR processes. The experimental study will enable the researchers to quantitatively define the levels of user involvement and system support in the IR process.

Acknowledgments

We would like to thank the anonymous reviewers for insightful comments and constructive suggestions.

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