Conformity out of Diversity: Dynamics of Information Needs and Social Influence of Tags in Exploratory Information Search

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Abstract. We studied the dynamic effects of information needs and social influence of tags in an exploratory search task. Although initially differences in information needs led to diversity in tag choices, this diversity disappeared as participants collaboratively tagged the same set of resources. Our findings are in general consistent with the notion that people conform to the collective interpretation of contents in an information system. In addition, our results showed that conformity does not only arise out of imitation of behavior, but also from the same underlying semantic interpretation or knowledge structures of users as they engage in informal collaboration through the social tagging system. Implications for design of social information system are discussed.

Keywords: Exploratory search, tag choice, information needs diversity, semantic interpretation of tags

1 Introduction

Information seeking activities can be characterized as a form of problem solving (e.g., [6], [8], [14]), in which people are searching for and comprehending information to fulfill their information goals. However, there are often situations in which the information seeker has not yet developed well-defined information goals to guide their search. Instead, the information seeker may have to start with an abstract representation of information needs derived from a broader task context. In these situations, the information seeker has to engage in some forms of *exploratory information search*, through which information goals can be iteratively refined and enriched (e.g., [5], [7]). Recently, researchers have reasoned that the traditional search engines are insufficient for this kind of exploratory search [11]. Instead, many have proposed that the evolving Web 2.0 technologies have great potential for helping people to conduct exploratory information search. However, what is still lacking is a scientific understanding on the interactive cycle of tag-based exploratory search and tag creation in a typical social tagging system. The goal of this paper is to investigate

the processes involved in tagging behavior and how it is related to tag-based exploratory search.

Social tagging systems allow users to annotate, categorize and share information on web resources (links, papers, books, blogs etc.) by assigning tags to them and share the tagged resources with other members of the system. One major reason for the popularity of tagging systems arises from its benefits in supporting exploratory search [13], social navigation [12] and information sharing. Prior research on social tagging systems has primarily focused on characterizing aggregate patterns in tagging behavior (e.g., [3], [4], [9]). However, with a few exceptions [13], there is still a lack of scientific study on how social tags could facilitate exploratory information search.

One important question underlying the success of social tagging system is whether the tags created by the large number of users provide any useful information for others. Indeed, users in any knowledge sharing system may have different underlying motivations to seek and share information, and this may lead to a continuous growth of diversified tags in a single system. For example, a particular user may tag a book based on its content with a tag "Star Trek", while another user may tag the same book as "To read", referring to personal intent of this book. Nevertheless, in spite of the perceived unstructuredness, researchers (e.g. [3], [9]) have found long-term stability in tagging behavior. For example, by analyzing a set of data from del.icio.us, Golder & Huberman [7] supported that tag choices are influenced by tags created by other users, even if users may have different information needs when they tag. Sen et.al [16] showed that community influence can directly impact user's personal tendency in choosing tag vocabulary. A recent study by Rader and Wash [15], however, has raised questions regarding the social influence on tag choices. By analyzing a different set of data from del.icio.us using logistic regression techniques, they found that tag choices could be better explained by personal information needs, which provided evidence against the presumed social influence of tags.

A relevant question regarding this controversy is: what motivates a user's tag creation (or use) in a social tagging system: personal information needs or social influence? Specifically, we explored how the dynamic effect of social tags and information needs elicits different tag choices among users. Instead of characterizing just the overall aggregate patterns, we specifically focused on users' information needs to understand how different tag choices emerge. Additionally, we also investigated how people created tags and how tag could facilitate exploratory information search, and how they could be related to each other. To preview our results, we found that tag choices were not only influenced by the information needs of the user, but were also influenced by the semantic interpretation of existing tags. In addition, consistent with results by Millen D.R. et.al [13], we found that browsing was used most often in exploratory information search, and this finding could be explained by theory of *perceived information gain*.

2 Method

2.1 Participants and Platform

Thirty two participants (12 Male, 20 Female; average age =22.6 years, S.D. = 4.5) were recruited from the University of Illinois community. Most Participants rated themselves as moderate computer users with an experience of about 12 years (87.5% browse the web more than once a day).

CiteULike (www.citeulike.com), a research literature sharing website with tagging and search features, was used as our research platform. CiteULike allows users add links to papers and books, and add references from other digital libraries and optionally tag the available content for future reference. We chose CiteUlike mainly for its simplicity of use and the relative ease of creating a library containing book information from external websites. Because CiteULike has all the basic functions of social tagging systems and a large number of users, we believe that our results can be generalized to other systems. User activities including mouse events, URLs, time stamps, and contents of web pages were recorded for further analysis.

2.2 Tasks

The information resource consisted of 150 books that were imported directly from Books@Amazon.com. This "library" of books covered eight categories with approximately equal number of books in each category: Arts & Photography, Business & Investing, Children, Computers & Internet, Cooking, Food & Wine, Health, Mind & Body, Medical, and Self-Help. We designed eight exploratory search tasks to represent different information needs based on the eight categories of books. The search tasks thus provided an abstract representation of information needs for participants to explore the library. For example, participants were asked to find and tag books to recommend for a library in a *retirement community*. The other seven tasks are *Software Company, Local Arts Center, Traveler's Books, Career Center, Rehabilitation Center, Daycare Center, Wellness Center.*

During the experiment, participants were asked to search for books by browsing in the main library, choosing tags from the tag cloud, or using keywords to search. When participants decided to select the book, they were encouraged to create new tags or reuse existing tags for the selected book after reading the description of the book. Participants were instructed to imagine that they were working with a group of other co-workers who were also selecting books for the same or different organizations, and the tags that they created should be useful *not only to themselves but also to others*.

2.3 Analysis

The 32 participants were randomly divided into 4 sessions. In each session, each participant was randomly assigned to one of the eight tasks. In other words, there was exactly one participant assigned to each of the 8 tasks in each session. In addition to

controlling the same initial library, we imitated the social environment of tagging system by enabling participants to see all tags created by previous participants.

We compared the tags created by participants on different books across the 4 sessions to investigate how tag choices were influenced by tags created by previous participants. We use Latent semantic analysis (LSA, see [10]) to estimate the semantic relatedness between every set of new tags created and the existing tags in each book selected by the participants. LSA is a statistical technique for extracting and representing the similarity of meaning of words and passages by analysis of large bodies of text. The similarity between resulting vectors for words and contexts has been shown to closely mimic human judgments of meaning similarity. In the current analysis, we performed the LSA calculations through the web site at http://lsa.colorado.edu, using the general reading topic space with 300 factors.

3 Results

Participants selected about the same average number of books across all the sessions ($F(3, 21) = .249$, $p > 0.10$). On average, subjects created 4.76 tags (S.D. = 2.27) for each selected book. As users proceeded through the sessions, fewer tags were created for each selected book ($F(3, 21) = 3.110$, $p < .05$).

3.1 Tag Creation and Tag Choice

The mean number of unique tags assigned to each book decreased across sessions (See Table1), as confirmed by the significant linear downward trend ($F(1, 30) = 3.92$, $p < 0.05$). The decreasing number of unique tags suggests the increasing agreement among participants on the creation of tags to the current set of books.

Table 1. The mean number of unique tags created per book across sessions

Session	1	2	3	4
Number of unique tags	8.0	4.5	3.6	2.9

To understand how different information needs influenced the tag use, we extracted all book-selection episodes from all participants, and calculated the correlation between users' information needs and new tag creation episodes. We believe that tag creation was not solely based on books or tasks, but also on the book "selection" under different tasks, because the "selection" can represent how users interpret the search tasks. Fig. 1 shows how we represent the selections and tags between the task and book space. Each selection in the figure represented the selection of one of the 150 books given that the participant was given one of the eight search tasks. A new-selection between book *i* and task *j* therefore indicated that the participant was the first one to select book *i* under task *j*. Different users may create different selections based on their own information needs and interpretation of the tagged resources.

To measure the relationship between the search tasks and users' motivation to create new tags, we coded each selection as either new or old (1 and 0, respectively) and called this the "new-selection code", and coded each tag creation as either new or old (1 and 0, respectively) and called this the "new-tag code" (See Fig. 1).

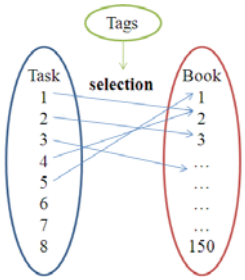

Fig. 1. Users selected books and created tags under different search tasks. Each book-selection episode is represented as an arrow from task to book in the figure. Each selection was associated with a set of tags created by the user. Users could repeat existing selections (select books that had been selected by other participants under the same search tasks before) or create new selections (select books that had not been selected before under the same search tasks). For old selections, tags could be new (not used before for the selected book, regardless of search tasks) or old (reused tags for the selected book).

Using the coding scheme described above, we calculated the correlation between the new-tag and new-selection codes, which reflected the extent to which the creation of new tags were related to the fact that participants were assigned to a new search task. A high correlation would imply that most of the tag creation occurred when participants were given a new search task. A low correlation would imply that creation of new tags were not related to the search tasks of the participants, in the sense that new tags were created equally often when participants were given the same or different search tasks.

Table 2. Correlation between the new-tag and new-selection codes in all book-selection episodes across sessions 2 to 4.

Session	2	3	4
Correlation between new-tag and new-selection codes	0.62	0.42	0.24

Table 2 shows that the correlation between the new-tag and new-selection codes steadily decreased across sessions. All correlations were significant ($p<0.05$), so was the obvious downward trend ($F(1, 22) = 4.21$, $p < 0.05$), which implied that the creation of new tags was more strongly related to differences in the search tasks (which imposed different information needs) early on than in the later stage. There was no significant difference between the numbers of tags created on the same or different selections. The results were consistent with the notion that ***as the number of tags increased, participants became more likely to agree with the existing tags***

associated with a book, even though these tags were associated with distinct selections as defined in Fig. 1.

To further understand whether users tended to conform to existing tags created by others, we calculated the LSA scores for all new tags created, and divided these "new-tag episodes" into whether they were associated with a new- or old-selection (see definitions in Fig. 1). Fig. 2 shows the mean LSA scores for the new-tag episodes. The main effect of new/old selections was not significant, but the interaction between new/old selections and sessions was significant ($F(2, 23) = 3.41$, $p < 0.05$). The LSA scores for episodes on old-selection were not significantly different across sessions, but the LSA scores for episodes on new selection in sessions 3 and 4 were significantly higher than that in sessions 2 and 3 respectively. In other words, the LSA scores stayed approximately at the same level for the old-selection episodes (books selected under the same search tasks) across sessions, but the LSA scores increased significantly across sessions for the new selection (books selected under different search tasks) episodes. The LSA score for the new-selection was significantly lower than that for the old-selection in sessions 2 and 3 ($p<0.05$).

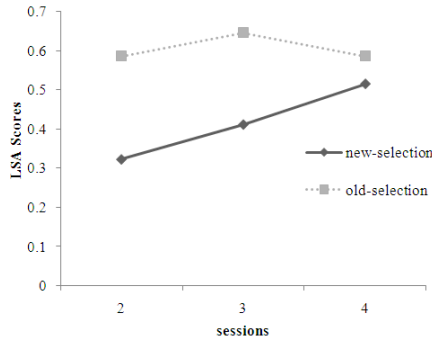

Fig. 2. The mean LSA scores for episodes with new tag creation under new- and old-selection. (In the first session all participants were given new search tasks, so the new-selection codes in all book-selection episodes in the first session were 1 and the correlation is not meaningful)

Results in Fig. 2 show that initially new tags created under the same search tasks were more semantically related than those created under different search tasks, but as more tags were created, this difference disappeared (see values at session 4). This provides further support to the notion that different search tasks (thus different information needs) have influence on tag choices, presumably because different information needs may prime users to focus on different aspects of a resource or have different interpretation of the information content. However, as the number of tags increased, their "bottom-up" influence on future tag creation increased and eventually outweighed the "top-down" influence from the information needs. This was confirmed by the same level of semantic relatedness for tags under same and different selections in session 4 (see Fig. 2). Over time, the semantic relatedness of tags for a resource increased irrespective of the information need, suggesting that the top-down

influence of information need was gradually replaced by the bottom-up influence of existing tags at the semantic level.

3.2 Tag-based Exploratory Information Search

Exploratory search strategy. In addition to the dynamics of information needs and social influence of tags, we also investigated into the characteristics of exploratory search in social tagging system. First, we extracted the strategies that participants used to select each book to understand how tags influence the use of strategies and how it varied across sessions. There were three major strategies used by the participants: *browsing*, *choosing tags from tag cloud* and *keyword searching*. Most participants selected books by browsing the book titles and tags on the main screen. We called this a *browsing* strategy. The *tag cloud* strategy was when participants clicked on any tag in the cloud and reached a list of books assigned with that tag. The third strategy was *keyword searching.* Participants clicked on "search" and typed in keywords to reach a list of books matching the keywords either in the title or tags.

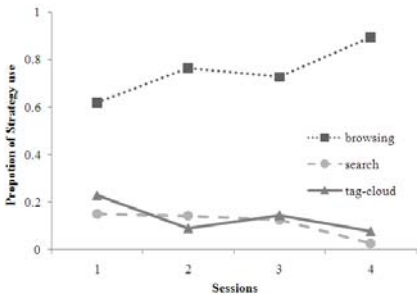

Fig. 3. Proportions of strategy use across sessions.

As shown in Fig. 3, the use proportions of the browsing strategy increased but the use of the other two strategies decreased across sessions. Analysis of variance showed that the main effect of strategy was significant ($F(2, 31) = 4.21$, $p < 0.05$), confirming the obviously higher proportion of the browsing strategy than the other two strategies. The strategy × sessions interaction was also significant ($F(6, 31) = 2.43$, $p < .05$), confirming the upward trend for the browsing strategy and the downward trends of the tag-cloud and search strategies.

The results were consistent with the conclusion by Millen [13] that community browsing (topic search) is the most frequently used search strategy in social bookmarking system. One possible reason was that the browsing strategy tends to have higher perceived information gain than the other two strategies. In this task, information gain can be defined in terms of the perceived usefulness of information cues in satisfying the information goal, i.e., the perception that the title words and tags could help participants to judge whether a book is relevant or not. Indeed, previous research has shown that selection of information search strategies is sensitive to the moment-to-moment measure of *information gain per unit time cost* ([1], [2], [8],

[14]). One important implication from these studies was the discovery that selection of information search strategy was more sensitive to the on-going evaluation of information gain than the overall efficiency of the strategy.

In the browsing strategy, the continuous evaluation of the title words and tags could lead to a high perceived information gain, as they provided on-going information for participants to judge the relevance of a book. Thus, the perceived moment-to-moment information gain per unit cost could actually increase as more tags were added to the books. We also believe that the higher perceived information gain for the browsing strategy was particularly prominent in exploratory search, as participants only had a rough idea of what they were looking for (as opposed to a well-defined information task in which, for example, a specific title or keywords were given). Thus, browsing not only allowed participants to find relevant books, but also allowed them to *refine and enrich their information goals* as specified in the search task. As a result, the perceived information gain was likely to be higher for the browsing strategies than the other two strategies.

Failed search episodes. To further test our assumption that tags will facilitate exploratory search, we counted the number of events when participants clicked on a book title, read its content description and decided *not* to select the book across sessions. We called each of these episodes a failed-search. If the tags associated with each book indeed provided more useful information for participants to judge the relevance of the book, the number of failed-search episodes should have decreased across sessions as more tags were assigned. Indeed, we found that the number of failed-search episodes decreased steadily across sessions as more tags were added to the library (table. 3), as confirmed by the significant linear downward trend ($F(1,30)=4.93, p<0.05$).

Table 3. Total number of failed-search episode for all participants across sessions.

Session	1	2	3	4
Total number of failed search	57	46	32	29

This pattern [1] was consistent with the idea that new tags provided higher information gain for participants as they browsed through the books and the new tags did help them to judge the whether the book should be selected or not without looking at the detailed description of the book. In other words, *participants' judgment on the relevance of books based on these tags actually improved as more tags were added.*

4 Discussion

The current findings provide a novel explanation of tag creation from the semantic level and support the assumption that tags can facilitate exploratory search. Through

[1] The count was pooled across all strategies as they involved the clicking on the book title before they could select the book.

the collaborative tagging effort by multiple users, the collective interpretation of information content becomes a more important factor that influences tagging behavior than differences in information needs, which is represented by the increasing semantic relatedness between tags. Not only did social tags influence how likely users may come up with new tags to describe the same information resource (Table 1), but when they did decide to create new tags, these new tags were closer in meaning to existing tags (Fig. 2). Researchers have argued that one reason why proportions of tag use tend to stabilize is because people tend to imitate others behavior [9]. Our results provide direct empirical evidence supporting this idea; but in addition to that, our results also highlight the dynamic interaction between personal information needs and social tagging behavior across time, which provides a more in-depth explanation to the stabilization pattern in large scale tagging systems.

Although initially different information needs led to creation of semantically different tags, as more tags were assigned to the resources across a session, new tags created became semantically more similar to existing tags (note that across sessions participants were given the exact same set of different information needs). In fact, in the last session, the level of semantic relatedness between new and existing tags created by participants with different information needs was about the same as those created by participants with the same information needs. The increase in semantic relatedness between new and existing tags across sessions is a novel finding that provides strong empirical support for the social nature of tags: As tags accumulated from the collaborative efforts from participants with different information needs, these tags presumably provided increasing depth and breadth to the description of the books. In fact, we believe that a major function of social tags is to provide semantic cues to the content of a resource, so that other users can utilize these semantic cues to estimate the relevance of a particular information resource with respect to their own information need. Thus, it is no surprise that users are conforming to certain underlying semantic structures through repeated interactions with the social tagging system. Our next set of studies will focus on extending the current findings to other "semantically rich" domains (e.g., biologists tagging research articles) to further test this idea.

Lastly, our results have significant implications for the design of next generation social tagging support tools. We established that social tags can facilitate information search because the failed search number significantly decreased across sessions and users chose the search strategy based on perceived information gain. Therefore, incorporating the semantic relatedness between existing tags would provide users a better representation for developing an understanding about current tags and help them to create new tags that would provide more informational value for the user and improve the effectiveness of information search. Given that our results show that the tagging process is sensitive to user's interpretation of existing tags, we speculate that different knowledge backgrounds may influence users' tagging and searching behavior by influencing their interpretation process. Our future study will look into how different knowledge structure may influence users' tagging behavior.

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