Investigating the Relationship between In-Situ User Expectations and Web Search Behavior

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ABSTRACT

Pre-adoption *expectations* often serve as an implicit reference point in users' evaluation of information systems and are closely associated with their goals of interactions, behaviors, and overall satisfaction. Previous studies have involved simulated user expectation as a feature in user modeling to model biased search actions. However, there is still little direct evidence revealing the relationships between users' expectations and their actual search behaviors. To address the gap, we collected 448 query sessions from participants in a controlled-lab user expectation study and gathered direct query-level feedback on their *expected information gains* (e.g., number of useful pages) and *expected search efforts* (e.g., clicks and dwell time) under each query. To our knowledge, this is the first attempt to explicitly examine the connections between different aspects of *in-situ* search expectations and user behaviors. Findings on user expectation advance our understanding of users' search decision-making and evaluation strategies and will also facilitate the design and evaluation of expectation-aware user models, metrics, and IR systems.

KEYWORDS

User search expectation; Interactive information retrieval; Web search; User cognitive bias

INTRODUCTION

With growing research in cognitive psychology and behavioral economics, investigating the cognitive bias is attracting tremendous attention to users' search behaviors in information retrieval (Azzopardi, 2021; Gomroki, Behzadi, Fattahi, & Salehi Fadardi, 2021; Lau & Coiera, 2007; White, 2013). Users estimate possible information gain/cost based on existing gain/cost and make the decision to maintain an optimal rate of gain and cost instead of pursuing the highest gain (Kahneman, 2003; Pirolli & Card, 1999; Tversky & Kahneman, 2019). In this process, users' expectation can represent their estimation and perception of gain and cost, help them form reference points, and affect their decision in information seeking (Abeler, Falk, Goette, & Huffman, 2011; Backus, Blake, Masterov, & Tadelis, 2022, 2017; Brown & Liu, 2022; Cox & Fisher, 2009; Kahneman, 2003; Liu & Han, 2020). Thus, their expectations create cognitive bias and lead to biased results in user modeling and evaluation. Previous studies have been engaged in modeling users' behaviors under influence of their expectations (N. Chen, Zhang, & Sakai, 2022; Moffat, Bailey, Scholer, & Thomas, 2017). However, there is little direct evidence showing relationships between users' expectations and actual search behaviors. Therefore, we conducted a user study to collect direct evidence about users' in-situ expectations regarding information gains and search efforts and their associated search behaviors at query level. This poster presents late-breaking results of our study, aiming to answer following research question:

RQ: What are the relationships between users' in-situ query level expectations and their actual search behaviors?

METHOD

To answer the RQ, we conducted a user study to collect data on both search interactions and users' explicit feedback on their expectations in each query segment. This user study assigned predefined complex search tasks of four types to 60 participants (undergraduate students from a U.S. research university). We adopted the four journalism tasks applied in previous studies and recruited participants not from the journalism major to control prior experience in these task types. The four task types include copy editing, story pitching, relationship, and interview preparation (Liu, Mitsui, Belkin, & Shah, 2019). These tasks have been scientifically demonstrated to be beneficial for motivating multi-round search interactions and regulating the possible impacts of a variety of contextual factors (Cole, Hendahewa, Belkin, & Shah, 2015; Li & Belkin, 2008). In addition, we chose two uncommon topics (1. coelacanth, 2. methane clathrates and global warming) to further control the possible variation in topic familiarity, as neither topic is likely to be familiar to our participant pool. When the participants submit a query, they are asked to complete a quick survey about their expectations of information gains and search efforts before browsing the retrieved documents. Survey questions are listed in Table 1. Here we define the expectation as users' perceived gain (e.g., useful pages) and cost (e.g., spending time) in each query segment. Besides their expectation labels, we also collected search behavioral data under each query for which user expectation feedback was collected. The behaviors include clicking, usefulness annotation, and spending/dwell time. The behavioral data is collected through a browser extension based on an open-source user study toolkit (J. Chen et al., 2021) with essential modifications for this study. After the data collection, we examined the normality of data distribution and chose statistical tests accordingly to find the associations between their expectations and actual behaviors. We further visualized the distributions of their expectations and behaviors and implemented a locally weighted linear regression (Loess) (Atkeson, Moore, & Schaal, 1997) to investigate the impacts of expectations on their search behaviors.

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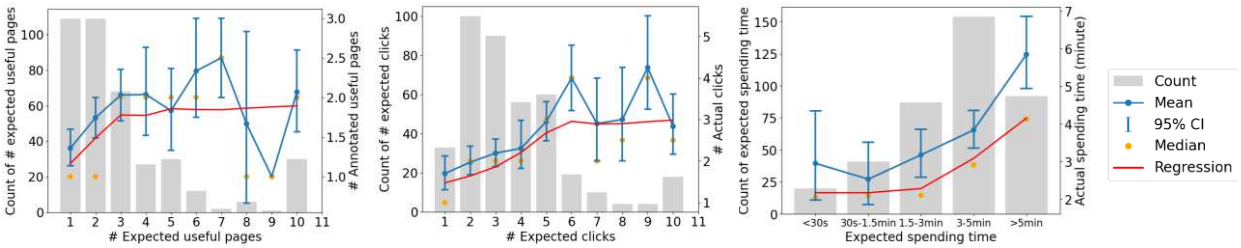
Expectation type	Question
Useful pages	How many useful pages do you expect to find? (Numeric)
Clicking results	How many results do you expect to click before obtaining the expected number of useful pages? (Numeric)
Spending/dwell time on content pages	How much time do you expect to spend on this search? (Ordinal) • fewer than 30 s (I can find the useful result instantly) • 30 s to 1.5 min (I can find the useful result quickly after inspecting it) • 1.5 min to 3 min (I need some time to read the results, but it won't take so long.) • 3 min to 5 min (I need some time to read the results.) • more than 5 min (I need more time to read the results carefully.)

Table 4. Pre-query questionnaire about expectations

RESULTS

As the result of the user study, we recruited 60 undergraduates as participants and collected 448 queries with expectation feedback on search gains and efforts and search behavioral data. The distributions of users' expectations are shown in Figure 1 as grey bars. Overall, multiple aspects of user expectations are positively correlated with users' behaviors of finding useful pages, clicks, and dwell time, and Spearman's rank coefficients are 0.203, 0.280, and 0.333 with $p < 0.01$, respectively. The positive correlations demonstrate that users with high expectations also have similar levels and trends in search behaviors to match their pre-search expectations. The blue line in Figure 1 represents the average values of search behaviors with a 95% confidence interval error bar. In general, the value of users' search behaviors increases with higher expectation values. However, when the expectations reach a point, there is a high variation in users' actual behaviors, and their behaviors may not increase accordingly. This inconsistency is also indicated by the red line, which is the result of Loess. Loess fits the behavior trends in different subranges of expectations. The trend is more linear when the number of expected useful pages is lower than three, the number of expected clicks is lower than six, or the expected spending time is high than 1.5 minutes. For the useful pages and clicks, when the expectations are higher than these values (for the spending time, when the expectation is lower than 1.5 minutes), the trends become flat because of the less correlation between their high expectations and high variance of behaviors. Although users have high expectations (expectations of high numbers of useful pages, clicks, and low spending time), they may not have compatible behaviors to match their expectations. This inconsistency reflects users' bounded rationality (e.g., optimism bias) in estimating their gain and cost in Web search. The heterogeneity in expectation-behavior correlations across varying ranges would not have been revealed without collecting explicit feedback and labels on in-situ search expectations in our user study.



(a) (b) (c)

Figure 8. Relationships between users' expectations and actual search behaviors

CONCLUSION

To investigate reference dependence and pave the way toward comprehensively studying cognitive biases in IR, we conducted a user study to collect data about user search expectations and actual behaviors in Web searching, including finding useful information, clicks, and dwell time on pages. The results indicate that users' pre-search expectations generally tend to be conservative (e.g., less than three expected useful pages and higher expected spending time) and that their expectations are positively correlated with their actual behaviors in general. Furthermore, the trends of their behaviors are more linear until users have high expectations (high number of useful pages, clicks, or low dwell time). However, when users have higher expectations, their behaviors may deviate from their pre-search expectations, leading to expectation disconfirmation scenarios in search and evaluation. These results can help us better understand users' search behaviors with the knowledge of their expectations and explore the impacts of implicit reference points and other cognitive biases. Future work can further examine the relationships between users' expectations and other factors, such as the search intention, emotional state, and query formulation strategies, and incorporate the knowledge about search expectations into user-centered IR evaluation.

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