Factors Influencing Search Failure in Digital Library Users: Postprint

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Date: 2023-07-26T00:00:00+00:00

Abstract

[Purpose/Significance] This study investigates the impact of task type, users' cognitive needs, and self-efficacy on search failure among digital library users. [Method/Process] Based on cognitive complexity, five types of tasks were designed, 30 library users were recruited, and data were collected through screen recording. [Results/Conclusion] The research indicates that task type and cognitive needs significantly influence overall task failure, while self-efficacy more strongly affects stage-specific query failures during the search process. Specifically: users are more likely to encounter task failure when completing tasks with higher cognitive complexity; users with high cognitive needs experience fewer task failures and rate their task completion level higher; users with high self-efficacy encounter fewer query failures during the search process.

Full Text

Research on Factors Affecting Search Failure of Digital Library Users

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Abstract

[**Purpose/Significance**] This study investigates how task type, users' cognitive needs, and self-efficacy influence search failure among digital library users. [**Method/Process**] Using cognitive complexity as a framework, we designed five types of search tasks and recruited 30 library users, collecting data through screen recording methods. [**Results/Conclusions**] The findings indicate that task type and cognitive needs significantly impact overall task failure, whereas self-efficacy primarily affects stage-specific query failures during the search process. Specifically, users are more likely to encounter task failure when completing tasks with higher cognitive complexity. Users with high cognitive needs experience fewer task failures and evaluate their task completion more positively. Users with high self-efficacy encounter fewer query failures during the retrieval process.

Keywords: search failure; cognitive complexity framework; need for cognition; self-efficacy

1. Introduction

Under the "Internet Plus" initiative, the quantity and variety of digital resources in university libraries have surged dramatically. Traditional Online Public Access Catalog (OPAC) systems can no longer meet users' evolving needs for digital resource retrieval. Consequently, academic libraries have integrated various systems including resource discovery platforms, the DuXiu e-book search system, and database navigation tools. However, the information retrieval process for library users remains complex, influenced by user motivation, system characteristics, and social context. As early as 1983, C.C. Kuhlthau [1-2] proposed a six-stage information search process model incorporating user emotions, cognition, and physical actions. T. Saracevic [3-4] examined the dynamic interaction between users and systems from both perspectives, proposing a stratified interaction model. T.D. Wilson [5] developed a cyclical information behavior model encompassing information needs, information-seeking behavior, and information system processing and use, considering the effects of mediating variables and motivational mechanisms on search behavior. These early models established user factors, contextual factors, and system factors as important influences on retrieval behavior.

Despite these frameworks, the complexity of the retrieval process and multiple influencing factors mean users still encounter difficulties and sometimes cannot obtain needed resources, experiencing search failure. This not only affects user experience but also reduces library resource utilization. Previous studies have examined various influencing factors on search behavior, with some investigating how query length and search entry points affect search failure. However, research comprehensively examining the impact of contextual factors and individual user characteristics on failure remains limited. Therefore, this study explores the relationship between tasks of varying cognitive complexity, user cognitive needs, self-efficacy, and the frequency of search failures to better understand the factors influencing retrieval failure and help users avoid it, thereby improving resource utilization.

2. Literature Review

To comprehensively collect relevant research on search failure factors, we conducted literature searches in both Chinese and English using CNKI and Web of Science. Chinese search terms included "search behavior," "search failure," "search stopping behavior" combined with "influencing factors," while English terms included "search behavior," "search failure," "search stop behavior" combined with "affecting factor." We supplemented this with literature on relationships between task type, cognitive needs, self-efficacy, demographic attributes, and search behavior. Additional relevant studies were identified through reference tracking.

The literature reveals that research on search failure primarily addresses three aspects: (1) **Query-level analysis** of failure causes. Longer query terms increase failure likelihood [6]; advanced and exact search functions correlate with zero-result scenarios [7]; search entry points significantly affect success/failure rates, with some studies suggesting title searches most often lead to failure [7] while others find keyword searches have higher failure than success rates [8]; Wu Dan [9] compared search point usage between mobile and non-mobile library users, identifying entry point design as crucial for success. (2) **User-level analysis** of failure causes. Studies show search experience, emotional attitude, and cognitive ability relate to failure. For instance, older adults rely on prior knowledge when searching health information but often fail while maintaining positive attitudes [10-11]; J. Sharit et al. [12] found higher cognitive ability correlates with fewer search failures. (3) **Contextual analysis** of failure causes. These studies examine task-related factors including difficulty, complexity, and type. Higher task difficulty increases abandonment when encountering zero results [13]; greater task complexity increases information-seeking failure rates [14]; task type also matters—users searching for well-defined information often fail, while those with ambiguous tasks find some relevant information and succeed more often [15].

Cognitive needs and self-efficacy are important user factors. Although limited research directly examines their impact on search failure, studies show high cognitive need users tend to explore more, adjust strategies, and identify useful information [16-17]. W.C. Wu et al. [17] found high cognitive need users exhibit less page-turning behavior and pay less attention to low-relevance documents, better capturing useful information. Self-efficacy is also a key factor in information retrieval [18]; W.H. Ren et al. [19] found higher self-efficacy helps users overcome negative emotions like confusion and frustration, enabling more effective searching, a finding echoed by F.Y. Kuo et al. [20] and N. Vibert et al. [21]. Beyond cognitive needs and self-efficacy, research has also examined cognitive style [22], cognitive ability [12], emotional attitude, and demographics [23-25].

Overall, research specifically on search failure remains limited, with most studies focusing on general search behavior characteristics. Studies on search failure concentrate on direct causes, with limited exploration of underlying influencing factors. Moreover, most research examines failure from macro perspectives, with few micro-level investigations of failure frequency. While libraries employ various methods to help users—training programs [26-27], database evaluation [28-29], reference services [30-32]—users still frequently encounter frustration and failure [33-34], affecting resource utilization. Therefore, analyzing search failure factors from the user perspective can help libraries better understand user difficulties and develop targeted services to improve resource accessibility and service quality.

3. Research Design

3.1 Conceptualization of Search Failure Different studies define search failure differently, primarily falling into two categories (see Table): **query failure** (per search record) and **task failure** (per task). Query failure definitions include: (1) zero search results [35-37]; (2) results exceeding a threshold value [38-39]; (3) zero clicks on result pages [6,34,38]; (4) user self-assessment via interview or questionnaire [34,41-42]. Task failure definitions include: (1) user judgment via questionnaire [17,43]; (2) researcher judgment based on comparing results with task requirements [44].

This study examines both query failure and task failure. Query failure is defined as occurring when users produce no clicks or save actions in a query [9]. Task failure is determined by questionnaire responses to "Do you feel you successfully completed this task?"—responses of 1, 2, or 3 indicate failure, while 4 or 5 indicate success.

3.2 Task Design and Research Hypotheses **3.2.1 Task Design.** L.W. Anderson et al. [45] proposed a taxonomy of educational objectives reflecting cognitive processes from simple to complex: remember, understand, apply, analyze, evaluate, create. B.J. Jansen et al. [46] designed tasks based on this taxonomy. D. Kelly et al. [47] selected five task types considering the difficulty of distinguishing application from analysis tasks. Following these frameworks, this study designed five tasks with progressively increasing cognitive complexity: memory, understanding, analysis, evaluation, and creation (see Table).

3.2.2 Scale Selection. Need for cognition represents an individual's tendency to engage in and enjoy effortful thinking, creating tension when unmet and motivating active organization and understanding [48-50]. High cognitive need individuals prefer active thinking and enjoy complex tasks [16,49]. The original 34-item scale by Cacioppo and Petty [51] was later refined. In 2005, Kuang Yi et al. [48] translated and validated a Chinese version for university students, resulting in a 17-item scale [16,48] using 5-point Likert scoring (1-5). This study adopts that scale.

Self-efficacy reflects users' subjective confidence in their retrieval abilities [52]. High-efficacy users set appropriate goals and achieve expected results [53], adjusting efforts to solve problems successfully. This study adopts the self-efficacy scale from S. Debowski et al. [52], comprising 14 items on a 5-point Likert scale (1-5).

3.2.3 Hypotheses. Based on literature review, no studies have directly examined search failure factors. Combining search failure and search behavior influence research, we propose three categories of hypotheses:

(1) H1: Relationship between task type and search failure - H1a: Users completing tasks with higher cognitive complexity will experience more query failures - H1b: Users completing tasks with higher cognitive complexity will experience more task failures - H1c: Users completing tasks with higher cognitive complexity will evaluate task completion lower

(2) H2: Relationship between cognitive needs and search failure - H2a: Users with high cognitive needs will experience fewer query failures - H2b: Users with high cognitive needs will experience fewer task failures - H2c: Users with high cognitive needs will evaluate task completion higher

(3) H3: Relationship between self-efficacy and search failure - H3a: Users with high self-efficacy will experience fewer query failures - H3b: Users with high self-efficacy will experience fewer task failures - H3c: Users with high self-efficacy will evaluate task completion higher

3.3 Data Coding 3.3.1 Key Behavior Coding. Drawing on coding schemes from W.C. Wu, D. Kelly et al. [17,43] and Cao Mei [54], we coded click and save behaviors during the search process. Click behaviors include page-turning and clicking result links; save behaviors include saving individual results or entire result pages. Detailed definitions appear in Table .

3.3.2 Search Failure Metrics. Based on key behavior coding and prior definitions, we developed statistical indicators for query and task failure (see Table).

3.4 Data Collection To ensure experimental validity, we first conducted pilot tests with two graduate students simulating the entire procedure, evaluating questionnaire design, task completion, and interview protocols. Based on feedback, we refined the experimental flow, questionnaire, and interview content. After confirming stability, we recruited 30 participants through Beijing Normal University's online forum from August 4-14, 2016. All participants completed tasks in a quiet, enclosed laboratory with standardized equipment.

4. Data Analysis and Discussion

4.1 Analysis of Cognitive Needs and Self-Efficacy The 17-item cognitive needs scale yielded total scores for each participant. The 30 participants' average cognitive need score was 57.13 (SD=10.80), ranging from 31 (lowest, participant 27) to 79 (highest, participant 8). Among the 17 items, "Very specific questions are not attractive to me" had the lowest mean (2.40), indicating participants generally found specific questions appealing. "I only care about what helps complete the task, not why or how" had the highest mean (4.10), suggesting participants focused on relevant information. Using the mean score to divide participants, independent samples t-test showed significant differences between groups (P=0.000). Participants scoring above the mean (n=13) formed the high cognitive needs group; those below (n=17) formed the low cognitive needs group (see Table).

The 14-item self-efficacy scale yielded an average score of 49.67 (SD=6.51), ranging from 35 to 60. The item "Can distinguish relevant from irrelevant information" had the highest mean (4.33), as did "Can identify what information to find when encountering problems" (4.23), indicating users generally could clarify topics and resist interference. Following prior research, we divided self-efficacy into three levels: scores above 56 (high, n=6, 20%), below 41 (low, n=4, 13.33%), and others (medium, n=20, 66.67%).

4.2 Search Failure Situation The 30 participants completed 5 tasks each (150 total tasks), generating 804 queries. Query failures totaled 516 (64.18%), higher than previous studies [7]. Of these, 394 involved no clicks and 134 involved clicks without saving. Participants averaged 3.46 query failures per task (SD=15.19), with a maximum of 30. Task failures totaled 58, averaging 1.9 per participant (38.67% failure rate) (see Table).

4.3 Relationships Among Task Type, Cognitive Needs, Self-Efficacy and Search Failure **4.3.1 Task Type and Search Failure.** As Table shows, task type did not significantly affect query failure count (P=0.185). Query failure rates across memory, understanding, analysis, evaluation, and creation tasks were 59.21%, 66.39%, 58.90%, 68.93%, and 65.75% respectively—all exceeding 50%. Evaluation tasks showed the highest rate (68.93%), averaging 4.73 query failures per task. Interviews revealed users struggled to find articles simultaneously covering both "bringing closer" and "estranging" aspects of social apps, leading to unsatisfactory results and repeated failures. Understanding (M=2.62) and analysis tasks (M=2.87) had lower average query failures, consistent with their lower cognitive complexity. Surprisingly, memory tasks (M=3.00) exceeded these, as users uncertain about Mo Yan's complete works underwent repeated searches.

Task type significantly affected task failure count and completion evaluation (P=0.000). As cognitive complexity increased, average task failures rose progressively. For the simplest memory tasks, only 2 users (6.67%, M=0.07) reported failure, versus 18 users (60%, M=0.60) for the most complex creation tasks. Evaluation (56.67%) and creation tasks (60%) both exceeded 50% failure rates. For memory tasks, over 90% rated completion as "very successful" (40%) or "comparatively successful" (53.33%). For creation tasks, 60% rated completion as "average" (40%) or "comparatively unsuccessful" (20%). Higher cognitive complexity demands more intellectual effort, making retrieval more complex and increasing failure likelihood while lowering evaluations.

4.3.2 Cognitive Needs and Search Failure. Table shows cognitive needs did not significantly affect query failure count, though low cognitive need users experienced more failures (M=3.71 vs 3.09) and higher failure rates (67.02% vs 60.18%). However, cognitive needs significantly impacted task failure count and completion evaluation. High cognitive need users experienced fewer task failures (M=0.29 vs 0.46) and lower failure rates (29.23% vs 45.88%). They also rated task completion higher (M=3.8 vs 3.52), with 70.77% rating tasks "very successful" or "comparatively successful" versus low cognitive need users' 31.76% "average" and 14.12% "comparatively unsuccessful" ratings. High cognitive need users' tendency for active thinking and problem-solving leads to fewer failures and higher evaluations.

4.3.3 Self-Efficacy and Search Failure. Analysis revealed significant differences in query failure counts across self-efficacy levels (p=0.009) (see Table). High-efficacy users experienced the fewest query failures (M=2.5), while low-efficacy users experienced the most (M=5.8), a 2.3-fold difference. Query failure rates were 58.59% (high), 61.90% (medium), and 76.82% (low). Though self-efficacy did not significantly affect task failure count or completion evaluation, trends showed low-efficacy users experienced double the task failures of high-efficacy users (M=0.6 vs 0.3). While 60% of low-efficacy users rated tasks "comparatively unsuccessful" or "average," 70% of high-efficacy users rated them "comparatively successful" or "very successful," with no high-efficacy users rating any task "comparatively unsuccessful" or "very unsuccessful."

4.4 Discussion 4.4.1 Analysis of Influencing Factors. To determine whether task type, cognitive needs, and self-efficacy independently affect search failure, we examined: (1) Correlations between cognitive needs, self-efficacy and demographic variables, academic literature reading frequency, and library resource usage. No significant correlations were found (P>0.05), indicating independent effects. (2) Inter-factor correlations and interaction effects. SPSS correlation tests showed no relationships between task type and cognitive needs or self-efficacy, confirming task type's independent effect. Cognitive needs and self-efficacy were significantly positively correlated (P<0.05, r=0.345). Multi-factor ANOVA revealed no significant interaction effects among the three factors on search failure, confirming their independent influence.

4.4.2 Discussion of Three Factors' Effects. SPSS one-way ANOVA results support five hypotheses (H1b, H1c, H2b, H2c, H3a) while rejecting four (H1a, H2a, H3b, H3c) (see Table).

Effects manifest as follows:

(1) **Task type** significantly affects task failure count and completion evaluation: higher cognitive complexity increases task failures and lowers evaluations. Failure rates from highest to lowest were creation, evaluation, analysis, understanding, and memory tasks—directly corresponding to cognitive complexity. Memory tasks require only information identification, with over 90% of users finding Mo Yan's works through one or more queries (6.67% failure rate, 4.3/5 rating). Understanding tasks require information organization, showing lower "very successful" ratings. Analysis tasks demand identification, compilation, and description, increasing

complexity and reducing "very successful" ratings to zero. Creation tasks require the most complex intellectual activities (identification, compilation, description, comparison, decision, production), resulting in the most failures and lowest evaluations. S.G. Hirsch [14] similarly found that considering tasks as more complex increases information-seeking failure rates. While task type didn't significantly affect query failures, data show query failures also increase with cognitive complexity. Overall, higher cognitive complexity leads to more query failures and poorer task outcomes.

(2) **Cognitive needs** significantly affect task failure count and completion evaluation: high cognitive need users experience significantly fewer task failures and rate completion higher. Cognitive needs reflect users' capacity for active thinking when facing tasks. High cognitive need users tend to think deeply [16,49], persistently attempt solutions, and successfully complete tasks, experiencing fewer failures and higher satisfaction. Low cognitive need users often fail to think and explore effectively, repeatedly using identical queries without success. For example, participant 23 (cognitive needs score=46, low group) completing the "social apps' impact on relationships" task used the query "WeChat interpersonal relationships" four times indirectly across eight attempts, despite it not yielding needed information. This aligns with prior research [16-17] showing high cognitive need users find effective information and become successful problem-solvers.

Regarding query failures, cognitive needs showed no significant effect, though low cognitive need users experienced more failures and more tortuous processes.

(3) **Self-efficacy** reflects users' subjective judgment of their ability to complete tasks [52]. High-efficacy users set appropriate goals and achieve expected results through strategy adjustments [50]. This study found self-efficacy significantly affects query failure count: high-efficacy users experienced significantly fewer query failures and lower failure rates, with smoother retrieval processes. This likely occurs because high-efficacy users demonstrate higher retrieval skills and greater effort. Process differences were notable: when completing evaluation tasks (analyzing whether social apps bring people closer or estrange them), high-efficacy users clearly understood goals, using queries like "social software" and "distance" to find relevant information, while low-efficacy users often entered entire task descriptions as long queries ("social software applications people's distance"), yielding poor results. For analysis tasks (e.g., post-flood disaster response), high-efficacy users decomposed tasks into "post-disaster reconstruction," "post-disaster hygiene," and "post-disaster epidemic" aspects to quickly locate resources, while low-efficacy users used broad queries like "flood disaster response" with poor results [53]. Though self-efficacy didn't significantly affect task failure, trends showed low-efficacy users experienced double the task failures of high-efficacy users, with more low-efficacy users rating tasks as "average" or "comparatively unsuccessful."

This aligns with research showing high-efficacy users have stronger motivation and persist when facing challenges [53,55].

Practical Implications: When retrieval systems detect users repeatedly submitting identical queries or producing no clicks across multiple searches, they can infer users are experiencing frustration and failure. To motivate low cognitive need users, systems could provide search tips and techniques [7], expand and recommend queries [56], or preserve search trails like e-commerce "footprints" to help users reflect and persist. Training programs and courses can directly improve users' information literacy [19] through failure case analysis, requirement decomposition, and task feature analysis [57], enhancing task interpretation and search skills. When users experience the joy of learning through searching, it may also help transform and improve abilities among those with lower cognitive needs or self-efficacy.

Limitations: This study's definition of search failure—no clicks or save actions on result pages—may be overly narrow, as lack of saving may reflect low satisfaction rather than outright failure. However, given search failure's complexity, this consistent definition allows exploratory investigation. Future research should combine objective data with subjective user evaluations. Additionally, this study used simulated tasks based on library websites rather than naturalistic user needs, limiting generalizability. Future research should capture authentic search data to better identify failure factors and develop more effective interventions to reduce search failure frequency and improve library resource usage.

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Author Contributions

Wang Kaifei: Data coding and analysis, manuscript writing and revision.
Huang Kun: Research design, failure factor analysis framework, logical structure design, manuscript revision.

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Abstract: [Purpose/Significance] This paper discusses how task type, need for cognition, and self-efficacy influence the frequency of failure among digital library users. [Method/Process] Using a cognitive complexity framework, the research designs five search tasks and recruits 30 participants from Beijing Normal University to conduct tasks, obtaining relevant data by recording participants' searching processes. [Result/Conclusion] Task type and need for cognition impact task failure, while self-efficacy impacts query failure. Users are more likely to encounter task failures when completing tasks of higher cognitive complexity. Users with higher cognitive needs encounter fewer task failures and have higher evaluations of task completion. Users with higher self-efficacy encounter fewer query failures.

Keywords: failed queries; cognitive complexity framework; need for cognition; self-efficacy

Note: Figure translations are in progress. See original paper for figures.