Cognitive Schema of User Information Resources: Influencing Factors, Analysis Methods, and Application Value (Postprint)

Authors: Lin Xin, Long Cunyu, Du Ying

Date: 2023-04-01T00:00:00+00:00

Abstract

[Purpose/Significance] From the perspective of research findings in cognitive psychology and cognitive science, cognitive schema plays a fundamental framework role in individual cognition and decision-making activities. Therefore, research on users' cognitive schemas for information resources helps to deepen the understanding of user information behavior and provides references for optimizing information resource management and information literacy education. [Method/Process] Starting from the schema concept in cognitive psychology, this study first analyzes the connotation and main characteristics of users' cognitive schemas for information resources, then examines its influencing factors, proposes a data-driven analysis method, and explores its application value in information resource organization and services, as well as information literacy education. [Results/Conclusions] Users' cognitive schemas for information resources are influenced by three types of factors: resources, users themselves, and systems; In big data environments, a data-driven analysis method for users' cognitive schemas of information resources should be adopted, utilizing UGC data and behavioral log data to achieve efficient and quantitative analysis of both group-level and individual-level cognitive schemas; In terms of applications, it can not only deepen research on the mechanisms and patterns of information behavior based on users' cognitive schemas for information resources, but also guide the construction of metadata systems from a user cognitive perspective and the organization of precise and intelligent services, and can also be used to advance the deepening of research and practice in information literacy education.

Full Text

User' s Cognitive Schema for Information Resources: Influencing Factors, Analysis Methods, and Application Value

Lin Xin, Long Cunyu, Du Ying
School of Information Management, Central China Normal University, Wuhan 430079

Abstract: [Purpose/Significance] According to research in cognitive psychology and cognitive science, cognitive schema plays a fundamental framing role in individual cognition and decision-making activities. Therefore, studying users' cognitive schema for information resources can help deepen our understanding of user information behavior and provide references for optimizing information resource management and information literacy education. [Method/Process] Starting from the concept of schema in cognitive psychology, this paper first analyzes the connotation and main characteristics of users' cognitive schema for information resources, then examines its influencing factors, proposes data-driven analysis methods, and discusses its application value in information resource organization and services, as well as information literacy education. [Result/Conclusion] Users' cognitive schema for information resources is influenced by three types of factors: resources, users themselves, and systems. In the big data environment, UGC data and behavior log data-driven analysis methods should be adopted to achieve efficient and quantitative analysis of user group and individual cognitive schemas. In terms of application, it can both deepen research on the mechanisms and patterns of information behavior based on users' cognitive schema for information resources, and guide the construction of metadata systems and the organization of precise and intelligent services from a user cognitive perspective. It can also be used to advance the deepening of information literacy education research and practice.

Keywords: user psychology; resource cognition; cognitive schema
Classification Number: G250
DOI: 10.13266/j.issn.0252-3116.2020.18.011

With the interdisciplinary integration of cognitive psychology, cognitive science, and library and information science (LIS), cognitive psychology and behavior have become important directions in user research within LIS, attracting attention from scholars both domestically and internationally and making progress in multiple fields. However, as an important theory in cognitive psychology and cognitive science, schema theory has not received sufficient attention in user information psychology research, lacking systematic investigation. Drawing on research and practical explorations of cognitive schema in psychology, education, and other fields [1-2], clarifying users' cognitive schema for information resources will help deepen our understanding of users' information resource seeking and utilization behaviors, and provide references for improving user-oriented information resource organization, services, and information literacy education. Therefore, this paper aims to analyze the connotation, character-

istics, influencing factors, and analysis methods of users' cognitive schema for information resources, and explore its application significance.

1 Literature Review

1.1 Cognitive Perspective on User Information Psychology and Behavior Research

With the integration of psychology, cognitive science, and information science, the cognitive perspective has become an important paradigm in user information psychology and behavior research, yielding rich research outcomes. Overall, the breadth and depth of integration between the cognitive perspective and user information psychology and behavior research continue to increase, showing an accelerating trend in publication volume. From the perspective of cognitive psychology and cognitive science, research findings on cognitive style [3], cognitive load [4], cognitive ability [5], mental models [6], cognitive structure [7], and sense-making [8] have been applied to varying degrees in user information psychology and behavior research. From the LIS perspective, research on information needs psychology [9], users' information seeking behaviors such as searching, browsing, and navigation [10-11], user information publishing behavior in the Web 2.0 environment [12], user information system utilization behavior in network environments [13], and network information absorption and utilization behavior [14] have all incorporated the cognitive perspective and achieved results in feature characterization, explanation, prediction, and control, promoting a comprehensive and in-depth understanding of user psychology and behavior. Additionally, based on relevant user information psychology and behavior findings, active research and exploration on information system construction and optimization have been conducted, such as improving information system design [4], website interface design [15], and information recommendation strategy design [16], yielding preliminary results.

1.2 Foundational Theory of Cognitive Schema

The concept of schema can be traced back at least to the 18th-century German philosopher Kant. Since then, psychologists such as F.C. Bartlett and J. Piaget introduced it to cognitive psychology, and through the further efforts of cognitive scientists including D. Rumelhart, R. Schank, W.F. Brewer, J.W. Alba, and J.R. Anderson, it has become an important concept in modern cognitive psychology and cognitive science, yielding rich foundational theoretical research. Regarding the characteristics of cognitive schema, D. Rumelhart and A. Ortony summarized them as containing variables, being embeddable, representing rather than defining knowledge, and being able to represent knowledge at different levels of abstraction [17]. P. Thorndyke summarized them into five aspects: abstractness, instantiation, predictability, inductiveness, and hierarchy [18]. In terms of functions, schema has specific functions such as information screening and filtering, information abstraction, prediction and inference, and

facilitating new knowledge learning [19-20]. For analyzing individuals' existing cognitive schemas, the most classic method is the recall method proposed by F.C. Bartlett in 1932 [21], after which various analytical methods have been proposed, including interviews, questionnaires, observation, concept association, and small-scale experiments [14, 22]. Regarding the acquisition and development of cognitive schema, J. Piaget' s assimilation-accommodation theory is particularly representative, positing that individuals can increase the content of cognitive schemas through the assimilation process, while through the accommodation process they can improve existing schemas and form new ones [23].

1.3 Application Research on Cognitive Schema

In recent years, the focus of cognitive schema research has shifted to application studies, yielding rich results. The following examples from psychology, education, product design, and LIS illustrate this trend. As one of the originating disciplines of cognitive schema research, psychology has conducted numerous explorations in application, focusing on the cognitive schemas of specific subjects or objects and their influencing factors, as well as explaining, predicting, and controlling related psychological phenomena based on cognitive schema, such as research on infant face schema effects [24] and the influence of cultural schema on language [25]. The field of education is an important area where cognitive schema theory has been applied early and effectively, with research and practice covering foreign language teaching, mathematics, geography, physics, Chinese language, and other subjects [26-28], addressing the core problem of how to use cognitive schema to improve teaching effectiveness. In product design, the focus of cognitive schema application research is to guide related product design by analyzing target users' cognitive schemas, thereby improving product usage experience. For example, Fu Jiuqiang et al. explored the design of children's programming pop-up books based on cognitive schema [29], while Chen Guoying et al. discussed the interaction design of traditional craft APPs based on cognitive schema [30]. Specifically in the LIS field, Jiang Yongfu and Liu Jingru as early as 1999 explored the influence of users' cognitive schemas on information selection, integration, and understanding [31]; Zhu Yuanliang et al. analyzed the influence of users' existing schemas on online reading and proposed improvement strategies [32]; Pu Hongyu and Ma Jie et al. proposed a deep reading-driven model based on cognitive schema theory, discussing the differences between shallow and deep reading [33]; Chen Hong proposed implementation strategies for promoting reading in university libraries based on cognitive schema theory [34]; Liu Chunnian et al. studied the quality signal transmission mechanism and effects of e-commerce platforms based on cognitive schema [35].

Overall, the LIS field has not only applied relevant achievements from cognitive science to deepen the understanding of user psychology and behavior but also used them to guide information system construction and improve information service experiences. Its integration with cognitive science and cognitive psychol-

ogy has been relatively deep and will continue to deepen. Regarding cognitive schema, its foundational theoretical research is relatively mature, and application research is developing in depth, achieving successful applications in multiple fields and providing reference examples for application research in the LIS field. However, although the LIS field has begun preliminary exploration of cognitive schema applications, except for literature [32] which involves users' cognitive schema for information resources, other studies mostly focus on users' cognitive schemas for specific knowledge objects. Therefore, conducting research on users' cognitive schema for information resources is not only necessary to adapt to the trend of disciplinary integration but also helps deepen the understanding of users' information psychology and behavior, providing references for improving information resource organization, services, and information literacy education. As an exploratory study on users' cognitive schema for information resources, this paper focuses on discussing its connotation and characteristics, influencing factors, proposing analysis methods adapted to the current information environment, and analyzing its application value, thereby providing references for expanding research ideas on user information psychology and behavior and for deepening research and practical exploration of users' cognitive schema for information resources.

2 Connotation and Characteristics of Users' Cognitive Schema for Information Resources

2.1 Connotation of Users'Cognitive Schema for Information Resources

When the concept of cognitive schema was first formed, Kant defined it as "the rule for constructing concepts in a general way." Since then, F.C. Bartlett and J. Piaget respectively defined it as "an active organization of past reactions or past experiences" [23] and "the structure or organization of action" [26]. In the 1970s and 1980s, based on research findings from information science, computer science, and psychology, the concept of cognitive schema evolved again and continues to be used today. Several representative definitions are: schema is a knowledge system or mental structure that represents general conceptual knowledge stored in memory [20]; schema is a set of knowledge that represents a class of procedures, perceptions, objects, events, time sequences, or social situations, providing a framework structure for concepts that can be instantiated or filled with characteristics of the represented object [21]; schema is organized knowledge about objects or events, obtained based on past experience and usable to guide current cognition or action [36]. Although different scholars have provided different definitions, their core connotation is basically consistent: based on individual experience, it is a kind of knowledge or cognitive structure/framework used to represent concepts, situations, events, and actions. It is an abstract generalization of a class of things, can be used to organize scattered stimuli, information, and data, and includes both variable and fixed content, which can be regarded as a questionnaire with blanks to be filled in [37-38]. For example, the schema for the animal "cat" includes fixed information such as "cat is a

mammal" and "has four legs," while variable content includes breed, size, color, and name. Referring to the definition of schema in cognitive psychology, users' cognitive schema for information resources can be defined as: the cognitive schema formed by individual or group users based on their cognitive experience to represent information resources. The fixed part of this schema reflects the common characteristics of information resources and helps users distinguish information resources from other types of cognitive objects; the variable part reflects the individual characteristics of information resources and helps users recognize the features of specific information resources and distinguish between different information resources.

2.2 Characteristics of Users' Cognitive Schema for Information Resources

Referring to domestic and international summaries of cognitive schemas and combining them with the cognitive characteristics of information resources, the main characteristics of users' cognitive schema for information resources can be summarized as stability, difference, development, and hierarchy. Stability means that once users' cognitive schema for information resources is formed, it will remain stable for a relatively long period. This characteristic stems from two aspects: first, the types of resource attributes contained in users' cognitive schema are relatively stable and will not change easily; second, the effective addition of new attributes to the cognitive schema requires the premise of understanding the meaning of the attribute' s corresponding values, which often involves the improvement of users' cognitive abilities and cannot be achieved overnight. Difference means that due to the influence of subjective and objective factors such as users' individual cognitive experience, ability, and goals, the characteristics of information resources themselves, and the environment in which cognition occurs, cognitive schemas will show certain inconsistencies among different users, when the same user faces different information resources, or in different cognitive contexts. Development means that with the accumulation of users' experience in cognizing information resources or changes in cognitive ability, their cognitive schema for information resources will also change slowly. This change can be bidirectional: with the accumulation of experience and improvement of cognitive ability, the attribute characteristics contained in users' cognitive schema for information resources will become increasingly rich; but with the decline of cognitive ability and reduction of cognitive practice, the attribute characteristics contained in users' cognitive schema for information resources may also decrease. Hierarchy means that each attribute characteristic contained in users' cognitive schema for information resources can also be regarded as a cognitive object with its specific cognitive schema. It should be noted that lower-level attribute characteristics provide semantic information for higher-level attribute characteristics.

3 Influencing Factors of Users' Cognitive Schema for Information Resources

In the practice of information resource cognition, users' actually adopted cognitive schema is mainly influenced by resources, users, and systems. Among them, resource factors determine the boundary of cognitive schema, user factors determine which factors users can or are willing to incorporate into their cognitive schema, and system factors determine which resource attribute features are available in a specific information system. The relationship between the three and users' actually adopted cognitive schema is shown in Figure 1 [Figure 1: see original paper], that is, users' cognitive schema for information resources under the influence of user factors and system factors are both subsets of users' cognitive schema for information resources under the influence of resource factors, and the intersection between the two is the cognitive schema actually adopted by users.

3.1 Resource Factors

Resource factors affect users' cognitive schema for information resources because different types or subjects of information resources have different characteristics, and users need to consider different attribute features when discriminating and selecting them, thus forming different cognitive schemas. First, different types of resources have different attribute features. Some attribute features of information resources are attached to resource types, and as resource types change, the set of attribute features they contain also changes. Typical divisions include: (1) Different literature resource types have different attribute features—for example, books have a publisher attribute, while journals and patents do not; dissertations have an advisor attribute, while other literature resource types do not. (2) Physical information resources and digital information resources have different attribute features—for example, physical resources have attributes such as copy number, collection location, and collection format, which digital information resources do not have; digital information resources have attributes such as media format and file size, which physical resources do not have. (3) Different media types of digital information resources also have different attribute features—for example, images and videos have resolution attributes, while audio and text do not; audio and video have duration attributes, while images and text do not. Second, different subjects of information resources have different attribute features. Different subjects of information resources often follow different norms during creation, resulting in some unique attribute features for different subjects, thereby affecting the formation of users' cognitive schemas. For example, the subject of novels can often be decomposed into three aspects: characters, environment, and plot; while academic monographs can be decomposed into research objects, research methods, research facets (such as application, problems, influencing factors, mechanisms, systems, models, etc.), and research conditions. Third, for different types or subjects of information resources, users focus on different points, leading to some commonly owned attribute features not neces-

sarily appearing in users' cognitive schemas. For example, language style is an important factor in novel cognition but is less important in academic literature.

3.2 User Factors

In information resource cognition activities, users themselves mainly influence their actually adopted cognitive schema from three aspects: schema acquisition status, cognitive ability, and cognitive goals. First, the influence of schema acquisition status. According to J. Piaget' s cognitive schema assimilation-accommodation theory, individuals always prioritize the assimilation mechanism when cognizing, and only when the assimilation mechanism fails will the accommodation mechanism operate to enrich and improve their cognitive schema. Users' information resource cognitive activities have begun since childhood when reading children' s books and textbooks; therefore, overall, users have already acquired certain cognitive schemas, although they may not be complete. Starting from this point, when users cognize information resources, they can always assimilate the resources to be cognized into their existing cognitive schemas, so without intervention, they often tend to use their already acquired existing schemas as the actually adopted cognitive schemas. To verify this, this study used first- and second-year undergraduate information resource management students as novice users and LIS doctoral students and young teachers as expert users to compare their schema differences in cognizing journal articles. The experiment selected 15 novice users and 15 expert users as subjects, asking them to read the same article and then inquiring about which attribute features they paid attention to. The results showed that novice users mainly focused on content features of the paper, including subject, research methods, and research objects, while expert users, in addition to content features, also paid attention to source journal, publication date, author, and author affiliation. Post-experiment interviews revealed that novice users lacked specialized learning on academic paper cognition methods and rich experience in reading academic papers, resulting in their continuation of cognitive schemas formed in junior and senior high school, almost failing to recognize features beyond content; while expert users, through the accommodation mechanism of cognitive schemas in past learning and practical experience, formed more complete academic paper cognitive schemas, enabling them to more comprehensively recognize various features of papers. Second, the influence of cognitive ability. In cognitive practice, users may be forced to abandon lower-level cognitive schemas (which focus more on resource detail features and emphasize differences between resources) due to their cognitive ability limitations, and instead assimilate the resources to be cognized into higher-level schemas. To verify this viewpoint, based on the novice vs. expert user comparison experiment, another cognitive experiment was conducted on expert users. This task involved selecting two search terms– "information organization," which all subjects were familiar with, and "high-energy physics," which all subjects were unfamiliar with–and asking subjects to select 10 high-quality journal papers from CNKI search results within a given time. The results showed that when selecting papers related

to "information organization," subjects all considered the attributes of journal name and author, while when selecting papers related to "high-energy physics," they did not consider these two pieces of information but only considered more general attributes such as subject, publication date, and author affiliation. Post-experiment interviews revealed that all subjects lacked understanding of the "high-energy physics" field, neither knowing which journals were important nor understanding well-known scholars in the field, and given the limited time, it was impossible to check journal and author information one by one, so they could only refer to the LIS field' s experience in judging timeliness and the level of author affiliations (such as national laboratories, "985" universities, etc.) for judgment. Third, the influence of cognitive goals. Users always have specific purposes when conducting information resource cognition activities, and under different cognitive goals, the optimal cognitive schemas they need differ. For example, if the goal is to search for an e-book from the library for reading, the cognition process needs to focus on attributes such as file format, whether it can be downloaded, and whether it can be browsed online, without needing to pay attention to attributes such as the number of paper copies, collection location, and whether it can be borrowed. To reduce cognitive load, users will dynamically adjust based on historical cognitive experience or predictions of cognitive goals, assimilating some elements of their cognitive schema for such information resources to higher levels, or even adjusting the cognitive order of some elements, thus forming a cognitive schema adapted to the cognitive goals.

3.3 System Factors

In specific information systems, users' actually applied cognitive schema is obviously influenced by the information provided by the system, that is, users' cognitive schema for information resources is a subset of the metadata of information resources in the system. On the one hand, for metadata items not provided by the system, users' cognitive schema cannot possibly contain the corresponding attributes. Taking book cognition as an example, the book community website "Douban Reading" includes user ratings, number of reviewers (read, reading, want to read), and other information reflecting book popularity, which is not yet covered by most libraries' OPAC information; correspondingly, library OPAC includes metadata items such as subject classification and subject terms, which "Douban Reading" does not cover. Obviously, when users use "Douban Reading," they will cut attributes such as subject classification and subject terms from their cognitive schema, and when using OPAC, they will remove user ratings and popularity information from their cognitive schema, thus forming differentiated users' cognitive schema for information resources adapted to the used system. On the other hand, for the same attribute feature in the cognitive schema, when users do not have a complete cognitive schema for attribute features, different system processing methods may affect whether users have the cognitive ability, thereby affecting their cognitive schema for information resources. Taking journal papers in unfamiliar fields as an example, the source journal attribute plays an important role in helping users judge paper

authority, but because users are unfamiliar with it, displaying the journal name may lead users to ignore this attribute during cognition, while displaying its inclusion status in important index databases (such as SSCI, SCI, CSSCI, EI, etc.) will fall within users' cognitive ability range, thus incorporating it into the cognitive schema.

4 Data-Driven Analysis Methods for Users' Cognitive Schema for Information Resources

With the advancement of informatization, especially the formation of the big data environment and the development of big data analysis methods, massive data resources reflecting users' cognitive schema for information resources have accumulated on the Internet, providing both data and technical foundations for data-driven analysis of users' cognitive schema for information resources. Moreover, compared with currently widely used analysis methods based on social surveys and small-scale experiments, adopting data-driven analysis methods for users' cognitive schema for information resources can bring about significant efficiency improvements, enabling both efficient analysis of multi-group or individual users'cognitive schemas for information resources and using full-scale data as analysis objects to improve the completeness of analysis results. Based on this, this paper proposes to construct UGC data-driven and behavior log data-driven analysis models for users' cognitive schema for information resources for different applicable scenarios.

4.1 UGC Data-Driven Analysis of Users' Cognitive Schema for Information Resources

With the development of Web 2.0, while using information resources, users have published massive amounts of UGC data in online communities, social networking sites, or website interaction sections. These data often contain users' cognition of information resources, so using them as data sources to extract and analyze the attribute features of information resources involved can summarize users' cognitive schema for information resources. To achieve automated analysis, a UGC data-driven user group/individual cognitive schema analysis model is constructed as shown in Figure 2 [Figure 2: see original paper], mainly including three modules: (1) Construction of users' cognitive schema for information resources from a global perspective, drawing on attribute feature set extraction strategies in review mining [39-40], extracting attribute features of information resources from massive UGC data, mining association relationships between attribute features, establishing comprehensive and hierarchical users' cognitive schema for information resources with full feature coverage; simultaneously establishing attribute dictionaries, attribute synonym dictionaries, and mapping relationships between attributes and attribute values to provide support for analyzing user group/individual cognitive schema for information resources; (2) Based on machine learning, extracting attribute features involved in user group/individual UGC data, using the attribute features in the global perspec-

tive users' cognitive schema for information resources as the target classification system, adopting appropriate machine learning strategies to perform multi-label classification on each piece of UGC data, establishing associations between UGC data and attribute features; (3) Based on the global perspective users' cognitive schema for information resources, constructing user group/individual cognitive schema for information resources, after obtaining the attribute features corresponding to each piece of UGC data, setting thresholds to filter out overly low-frequency attribute features, then processing based on the association relationships between attribute features in the global perspective users' cognitive schema for information resources to form systematic user group/individual cognitive schema for information resources. It should be noted that, first, users are basically not subject to any external constraints when publishing UGC data, so when UGC data is abundant, relatively comprehensive and systematic users' cognitive schema for information resources can be obtained; second, users have typical irrational characteristics in UGC data publishing, that is, they often do not think deeply when publishing UGC, and the published information may not fully reflect what they have cognized [41], which leads to the possibility that when UGC data scale is small, the mined users' cognitive schema for information resources may not be comprehensive enough.

4.2 Behavior Log Data-Driven Analysis of Users' Cognitive Schema for Information Resources

In specific information systems, given that users' actually adopted cognitive schema is a subset of the metadata of information resources provided by the system, users' cognitive schema can be analyzed through their behavior logs in the system. The basic process of this method is: (1) Record user behavior information, that is, based on comprehensive analysis of possible user operation behaviors, screen out behaviors meaningful for cognitive schema analysis, such as mouse clicks, navigation function usage, search function usage, and gesture interaction on touch-screen devices, and clearly define the information items to be recorded, accordingly adding corresponding user behavior recording functions during system development or upgrading; (2) Collect user behavior information, to comprehensively collect user behavior information, especially for low-frequency users, continuous collection for a period of time is needed; (3) Clean user behavior logs, removing meaningless or obvious misoperation and cheating behavior data from the collected behavior logs to obtain log data usable for behavior analysis; (4) Parse user behavior logs, for different behavior types, adopt different strategies to achieve semanticization of user behavior data, mapping raw behavior data to metadata items of information resources that users interact with, for example, using query intent recognition technology to analyze which metadata information user search terms correspond to, using mapping relationships between behavior areas and metadata items to convert area information of mouse clicks into operation information on metadata items; (5) Based on the operation and display ratio of information resource metadata items, filter out overly low-frequency metadata items, and then establish users'

cognitive schema for information resources in specific information systems. It should be noted that this analysis method is only applicable for analyzing the cognitive schema for information resources that users adopt in specific systems and the importance of each attribute feature in users' cognitive schema for information resources; however, it cannot analyze whether users' cognitive schema for information resources contains attribute features not covered by the system' s metadata system. Therefore, the users' cognitive schema for information resources obtained through this method may have completeness deficiencies.

5 Application Value of Users' Cognitive Schema for Information Resources

The searching, evaluation, organization, and utilization of information resources are all premised on the cognition of information resources. Therefore, conducting research on users' cognitive schema for information resources helps deepen the understanding of related user behaviors and guides the advancement of user-oriented information resource organization and services. Meanwhile, a reasonable cognitive schema for information resources will help improve users' abilities to search for, evaluate, organize, and utilize information resources. Therefore, the cultivation of related abilities in information literacy can be regarded as a cognitive schema acquisition problem, and research on users' cognitive schema for information resources will also help promote the deepening of information literacy education practice.

5.1 Deepening Research on Information Seeking and Organization Behaviors

Among users' series of information behaviors, information seeking and organization behaviors are more closely related to information resource cognition. In information seeking activities, whether it is the selection of information sources, navigation strategies, and search strategies, or search result interaction based on faceted search and quality evaluation and screening before information resource utilization, these user behaviors are influenced by their cognitive schema for information resources. In personal information organization activities, users' behavior in revealing information resource features is also influenced by their cognitive schema, that is, users can only select relevant information resource attribute features as entry points within their cognitive schema. In terms of influence mode, it is reflected both in whether some behaviors occur and in the frequency of some behaviors. For the former, when all users in a group or an individual' s cognitive schema does not contain a certain attribute feature of information resources, information behaviors related to that attribute will not occur, for example, users' book cognitive schema generally does not contain ISBN information, which is reflected in behavior as users not using ISBN as a search point; for the latter, when only a small number of users in a group contain a certain attribute feature in their cognitive schema or the importance of that attribute feature is weak, it will be reflected as less information behavior related

to these attributes, and vice versa. Based on this, users' cognitive schema for information resources can be incorporated as an influencing factor into research on users' information seeking and organization behaviors, thereby helping to more comprehensively and deeply understand the mechanisms of users' information seeking and organization behaviors, characterize user behavior features, predict user information behaviors, and provide references for behavior guidance and control.

5.2 Optimizing Information Resource Organization and Services

Given that cognitive schema plays a framing role in user cognition and decision-making, reflecting the resource attribute features that users pay attention to, applying it to information resource organization and services helps deepen the user-oriented concept and improve resource organization quality and service experience. On the one hand, users' cognitive schema for information resources can be regarded as a user-perspective metadata system for information resources, so it can be used as a framework for information resource annotation to fully reveal resource features that users care about. On the basis of annotation, RDF triples can also be used for semantic description of annotation results to achieve computer-understandable annotation results. Given that users' cognitive schema for information resources changes with resource type, subject, and user, this model will help promote the development of information resource annotation toward refinement, more systematically and comprehensively revealing features of specific types and domain information resources while also enhancing their user group targeting and better conforming to users' cognitive abilities and habits. On the other hand, in the organization of information resource services, taking users' cognitive schema for information resources as a factor into comprehensive consideration helps improve user experience from aspects such as understandability and precision, and advance information resource services toward intelligence. Typical application scenarios include: in automatic summarization generation and structured display service organization, group and personalized information resource summary frameworks can be constructed according to users' cognitive schema for information resources, thereby helping users quickly and comprehensively cognize information resources according to their cognitive habits while also helping avoid information overload; in information resource discovery service organization, multi-dimensional navigation systems, search point settings, query intent recognition, and semantic faceted system design in faceted search can be conducted according to users' cognitive schema for information resources, facilitating users to search for information and explore search results according to their cognitive habits, better supporting users in efficient searching and judgment decision-making; in personalized information recommendation service organization, semantic interest models and information resource profiling tag system frameworks can be constructed according to users' cognitive schema for information resources, providing support for precise recommendation of information resources.

5.3 Improving Information Literacy Education

The cultivation of information seeking and information resource quality judgment abilities is an important content of information literacy education and is also more closely related to users' cognitive schema for information resources. From the perspective of learning psychology, information seeking and information resource quality judgment can be regarded as problems of enriching and improving cognitive schemas. Moreover, from research and practice in other educational fields, improving teaching effectiveness based on schema acquisition has become a consensus [42]. Starting from this point, the deepening of information literacy education theory research and practice can be promoted from multiple aspects. First, construct an information resource cognitive schema system for information literacy education, that is, for specific information resource types, subject domains, and cognitive goals, combined with the current information environment, construct a target schema system for information resource cognition (including attribute feature cognitive schemas) as the ultimate goal of information literacy education. Second, guided by J. Piaget' s cognitive schema assimilation-accommodation theory, study how to provide support for learners in information literacy education from aspects such as learning resource construction, cultivation method innovation, and cultivation path design, to promote them to complete the accommodation process of information resource cognitive schema more efficiently and develop more complete and systematic information resource cognitive schemas. Third, given that cognitive ability affects the cognitive schema actually adopted by users in information resource cognition through the assimilation mechanism of cognitive schema, it is necessary to simultaneously promote the cultivation of cognitive abilities matching information resource cognitive schema, making up for learners' cognitive ability shortcomings, so that their cognitive schema framework can truly play a role in information seeking and quality judgment practice.

References

[1] PLANT K, STANTON N. The explanatory power of schema theory: theoretical foundations and future applications in ergonomics[J]. Ergonomics, 2013, 56(1): 1-15.

[2] ARIZA-VARGAS L, DOMINGUEZ-ESCRIBANO M, LOPEZ-BE DOYA J, et al. The effect of anxiety on the ability to learn gymnastic skills: a study based on the schema theory[J]. Sport psychologist, 2011, 25(2): 127-143.

[3] KESSLER S H, ZILLICH A F. Searching online for information about vaccination: assessing the influence of user-specific cognitive factors using eye-tracking[J]. Health communication, 2019, 34(10): 1150-1158.

[4] WANG Q, YANG S, CAO Z, et al. An eye-tracking study of website complexity from cognitive load perspective[J]. Decision support systems, 2014, 62(1246): 1-10.

[5] LIN Xin, ZHOU Zhi. Analysis of the influence of user cognition on tagging behavior: an empirical analysis based on movie social tagging data[J]. Information studies: theory & application, 2015, 38(10): 85-88.

[6] RAHROVANI S, MIRZABEIGI M, ABBASPOUR J. The trained and untrained users' mental models compatibility with the icons of search modules in Iranian digital library applications[J]. Library hi tech, 2017, 35(2): 290-302.

[7] ZHANG Bin, JIA Qian. The cognitive structure and evolution of library and information science in China[J]. Journal of library science in China, 2014, 40(4): 30-47.

[8] LIU Ping, YE Fangqian, YANG Zhiwei. Research on interactive information retrieval model from the perspective of cognitive construction[J]. Library and information service, 2020(2): 93-101, 122.

[9] WANG Chongliang, CAO Jindan, ZOU Nannan. Theoretical analysis of the correlation between information users' cognitive needs and cognitive load[J]. Information science, 2019, 37(3): 141-145.

[10] KANG Menglan, ZHANG Min. A review of foreign research on adolescents' information retrieval strategies[J]. Digital library forum, 2019(5): 65-72.

[11] KE Qing, WANG Xiufeng, CHENG Ying. Research on the relationship between task complexity, user cognition, and Web navigation behavior[J]. Journal of the China society for scientific and technical information, 2016, 35(11): 1208-1222.

[12] HU Q, LIN X, HAN S, et al. An investigation of cross-cultural social tagging behaviours between Chinese and Americans[J]. The electronic library, 2018, 36(1): 103-118.

[13] HAN Zhengbiao. Review and prospect of foreign research on users' mental models of information retrieval systems[J]. Journal of the China society for scientific and technical information, 2018, 37(7): 668-677.

[14] DENG Weihua, YI Ming, LI Shujie. Research on online users' follow-up review information use behavior based on the "cognition-attitude-use" model[J]. Information and documentation services, 2018, 39(4): 71-79.

[15] KIM J, THOMAS P, SANKARANARAYANAN R, et al. What snippet size is needed in mobile web search[C]//NORDLIE R, PHARO N, FREUND L, et al. Proceedings of the 2017 conference on human information interaction and retrieval. New York: Association for Computing Machinery, 2017: 97-106.

[16] SHI Yu, HU Changping, SHI Yinghui. Research on user interest modeling based on cognition in personalized recommendation[J]. Information science, 2019, 37(6): 37-41.

[17] RUMELHART D, ORTONY A. The representation of knowledge in memory[M]//ANDERSON R C, SPIRO R J, MONTAGUE W E. Schooling and the acquisition of knowledge. New Jersey: John Wiley & Sons, Inc., 1977: 99-135.

[18] THORNDYKE P. Applications of schema theory in cognitive research[M]//ANDERSON J R, KOSSLYN S M. Tutorial in learning and memory. New York: W. H. Freeman & Co., 1984: 167-191.

[19] GILBOA A, MARLATTE H. Neurobiology of schemas and schema-mediated memory[J]. Trends in cognitive sciences, 2017, 21(8): 618-631.

[20] WANG Xiong. Research on mathematics learning based on schema[M]. Guilin: Guangxi Normal University Press, 2008: 9-21.

[21] BARTLETT F. Remembering: a study in experimental and social psychology[M]. Cambridge: Cambridge University Press, 1932.

[22] YUNCHENG J, GANG C, DAJUN Z, et al. Attachment avoidance is significantly related to attentional preference for infant faces: evidence from eye movement data[J]. Frontiers in psychology, 2017, 8(85): 1-10.

[23] WADSWORTH. Piaget' s theory of cognitive and affective development[M]. Translated by XU Mengqiu, SHEN Mingming. Xiamen: Xiamen University Press, 1989: 13-20.

[24] HOLFRETERICH S K C, PFISTER R, EL GAMMAL A T, et al. Endogenous testosterone and exogenous oxytocin influence the response to baby schema in the female brain[J]. Scientific reports, 2018, 8(1): 7672-7682.

[25] HE Xiumei, ZHANG Xiani, ZHANG Jijia, et al. The influence of cultural schema on spatial metaphor in kinship term semantic processing: evidence from Han Chinese and Mosuo people[J]. Acta psychologica sinica, 2015, 47(5): 584-599.

[26] YANG Yuan, XU Bing. Research on task-based reading teaching model from the perspective of schema theory[J]. Foreign language research, 2020(2): 1-7.

[27] JITENDRA A K, HARWELL M R, DUPUIS D N, et al. A randomized trial of the effects of schema-based instruction on proportional problem-solving for students with mathematics problem-solving difficulties[J]. Journal of learning disabilities, 2016, 50(3): 322-336.

[28] KANG Tongjie, CHEN Jige. Schema strategy for geography test review[J]. Teaching and management, 2018(25): 75-76.

[29] FU Jiuqiang, ZHANG Qianqian, SUN Yuanbo. Research on children' s programming pop-up book design from the perspective of schema theory[J]. Packaging engineering, 2020, 41(2): 36-43.

[30] CHEN Guoying, JI Yi, TAN Peng. Interaction design of traditional craft APPs based on cognitive schema[J]. Packaging engineering, 2019, 40(12): 249-253.

[31] JIANG Yongfu, LIU Jingru. Cognitive schema and information acceptance[J]. Library development, 1999(3): 2-3.

[32] ZHU Yuanliang, CAO Yi, WANG Yage, et al. Discussion on online reading based on schema theory[J]. Library and information service, 2018, 62(20): 14-23.

[33] PU Hongyu, MA Jie, GE Yan, et al. Deep reading-driven model and verification in new media environment: from the perspective of schema theory[J]. Library and information service, 2018, 62(20): 14-23.

[34] CHEN Hong. Research on university library reading promotion strategies based on "schema theory" [J]. Library work and study, 2016, 1(5): 34-37, 51.

[35] LIU Chunnian, ZHOU Tao, HUANG Jun. Research on quality signal transmission mechanism and effects of e-commerce platforms based on intelligence cognitive schema[J]. Journal of intelligence, 2019, 38(9): 198-207.

[36] PANKIN J. Schema theory[EB/OL]. [2020-03-23]. http://web.mit.edu/pankin/www/Schema_{{{Theory}}

[37] GALOTTI. Cognitive psychology[M]. 5th ed. Translated by WU Guohong, et al. Beijing: China Machine Press, 2016: 122-124.

[38] XIA R, XU F, ZONG C, et al. Dual sentiment analysis: considering two sides of one review[J]. IEEE transactions on knowledge and data engineering, 2015, 27(8): 2120-2133.

[39] ZHOU Qingqing, ZHANG Chengzhi. Fine-grained attribute extraction from online user reviews[J]. Journal of the China society for scientific and technical information, 2017, 36(5): 56-65.

[40] LIN Xin, LIANG Yu. Analysis of the manifestations and causes of irrational behavior in users' social tagging[J]. Digital library forum, 2016(12): 48-53.

[41] CUI Tingting, WANG Huan. Research on English micro-teaching model for resisting language attrition from the perspective of schema theory[J]. China educational technology, 2017(10): 130-135.

Author Contributions:
Lin Xin: Responsible for topic selection, paper writing and revision.
Long Cunyu: Responsible for experiment implementation, participated in initial draft writing.
Du Ying: Participated in experiment implementation and literature collection.

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