Un Modèle de Recherche Exploratoire pour l'Évaluation de ses Systèmes & Applications

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Abstract
Current evaluation methods of exploratory search systems are still incomplete as they are not fully based on a suitable model of the exploratory search process: as such they cannot be used to determine if they effectively support exploratory search behaviors and tasks. Aiming to elaborate evaluation methods based on an appropriate model of exploratory search, we propose in this paper a model of the exploratory search process compliant with the acknowledged exploratory search characteristics, and we present a first evaluation of this model.

Author Keywords
Exploratory search; Information Seeking; Exploratory Search Model; Model Evaluation.

CSS concepts
Information systems → Information storage systems

Résumé
Les moteurs de recherche exploratoire sont des systèmes visant à assister le processus d'exploration d'information. Les méthodes actuelles d'évaluation de ces moteurs ne sont pas adaptées pour vérifier s'ils assistent effectivement et complètement les comportements et tâches de recherche

exploratoire, car elles ne reposent pas sur un modèle approprié de ces comportements et tâches. Afin d'élaborer des méthodes d'évaluation basées sur une meilleure compréhension du processus d'exploration, nous proposons ici un modèle du processus de recherche exploratoire conforme aux caractéristiques reconnues de processus et présentons une première évaluation de ce modèle.

Mots Clés
Recherche exploratoire ; Recherche d'information ; Modèle de la recherche exploratoire ; Evaluation de modèle.

White's definition of Exploratory Search:

"[the term] exploratory search can be used to describe both an information-seeking problem context that is open-ended, persistent, and multifaceted, and an information seeking process that is opportunistic, iterative, and multi-tactical. […] Although almost all searches are in some way exploratory, it is not only the act of exploration that makes a search exploratory; the search must also include complex cognitive activities associated with knowledge acquisition and the development of cognitive skills".

Introduction

Exploratory search (ES) is a particular information seeking activity in terms of "problem context and/or strategies employed" [14]. In [13], White proposes a definition of ES which underlines the complexity of this activity (see the lateral bar).

Evaluating ES systems is still an open issue. One of the challenge is the ability of the evaluation methods to effectively assess whether users' ES behaviors and tasks are actually supported by the ES systems. One of the reasons is that these methods rely on a model of ES which is still loosely defined, or at least on a definition which is not yet clear and stable. Few evaluation methods are based explicitly on a process model and, when it is the case, they propose approaches that do not take into account the user's exploration process in its entirety, leading to models that do not exactly reflect the specificities of the ES task. For example, Wilson *et al.* [15] used Bates' model [1] and Belkin' model of information-seeking strategies [3], and Bozzon *et al.* [4] used Kuhlthau's model of information-seeking [7]. The two studies propose an evaluation of ES systems at a too low level, referring to basic actions such as click and select. However, there is an important gap between these basic actions and high-level activities which prevents the capture of a complete ES process.

Our goal is to design model-based evaluation methods that assess whether an ES system effectively supports ES behaviors and tasks. In order to design such methods, we need a model that reflects the ES process. The model of ES we are looking for is what Donald Norman called an *approximate model* [10]: it does not depict the whole ES process in detail or precisely, but it is "good enough for the purpose to which [it will be] applied" [11]. In our case, this model is designed to be accurate enough to support the elaboration of two evaluation methods of exploratory search systems, and not to describe the whole process exactly. The two evaluation methods based on the model are:

- An inspection method, in line with Nielsen's Heuristics evaluation ;
- A user testing method, with a given protocol.

Design Method of the Model

First, we studied if an existing model could be the approximate model we were looking for. To do this examination, we used the acknowledged characteristics of ES proposed by [12] (see Table 1.A.) as an analysis grid. We confronted five information seeking models with these characteristics: Ellis' model [5,6], Bates' model [2], Kuhlthau's model [7], and the two models of Marchionini [9] and [8]. We observed that none of these models exactly checked all the ES characteristics (see Table 1.B). It means that any of them provided description or characteristics of information seeking activity which completely matches with ES, which is a more particular and specific search activity.

However, we decided to keep the model which can be easily adapted to the ES process' characteristics and definition: this is the Ellis' model. Based on empirical studies, this model proposes a set of eight features characterizing the information seeking patterns of real information seekers. These features form a framework for information seeking [14]. They provide a "framework for a flexible model to underpin recommendations for information retrieval system design and evaluation" and they can be employed to derive a set of general recommendations [5]. The model does not specify the order in which the features are carried out: an information seeker is not "guaranteed to undergo an identical information-seeking process as outlined in the model" [14]. The model does not define either the interactions or interrelationships between the features. Each ES session is unique and unpredictable. The freedom in the process representation offered by these specific aspects of the model is really relevant for the design of our ES model. On the other hand, for a complete evaluation of an ES system, we should evaluate and facilitate in our model-based methods the transitions between the model features. In Ellis' model original form, this cannot be achieved. In any case, the model's description matches both our objective and the ES concept: it proposes a non-linear process without predefined sequences. As mentioned previously, the model needs to be adapted to better suit ES concept and its characteristics. Following this methodology, we designed our model of ES process by linking each feature to one or several characteristics of ES.

The Model of Exploratory Search

We use Ellis' model as a framework, and we adapt it to the ES characteristics in order to overcome the weaknesses identified in Table 1.B. The ten features of our model express typical ES *behaviors*, such as having an evolving information need or a serendipitous attitude. Consequently, the evaluation methods based on the model aim to verify if the evaluated system supports these ES behaviors. A search session always starts with **A.** *Define the search space* and ends with **J.** *Stop the search session*.

A. Define the search space (char 9, 10): The user starts her search session with an anomalous state of knowledge as a general context of search. She has a lack of knowledge and a vague objective of search, but not a specific plan to attain it. She will find an approach to her problem and may find an angle of attack.

B. (Re)Formulate the query (char 11): The user (re)formulates the problem with a fluctuating uncertainty. The formulation can be explicit or implicit: depending on the interface, the user may use the search bar or keep in mind her query for example.

C. Gather information (char. 5, 6): The user might not have one precise answer but an aggregate of relevant information which will help her to go further in her reflection and in her exploratory search process.

D. Put some information aside (char. 3, 4, 7): Throughout the search session, the user might put some information aside. She will probably come back to it to pursue/resume the exploration later.

E. Pinpoint result(s) (char. 2): The user wants more information on one element (query, answer, or the link between them, etc.). This feature is related to sense-making activities such as verifying information.

F. Change goal(s) (char 1, 4): The user decides to change or specify her search objective/goal.

G. Proceed backward/forward (char 1): The user can accomplish backward or forward steps when the pathway followed is not suitable for her.

H. Browse results: The user browses or scans the results given by the system.

I. Analyze results (char 10): The user selects one or multiple filters/facets to explore the information space. She tries to fit the results into an analysis framework (relevance). Then, she identifies and analyzes all results and possible paths that can be relevant.

J. Stop the search session (char 8): The user may never end her exploratory search. She can stop it for multiple reasons, and she may resume her search a few hours/days/weeks/months/years/… later.

Preliminary Validation of the Model

If we assume that a user achieving an ES session performs an ES process, we should be able to identify in their search process the *features* of our model of ES, and only them. If that is the case, the model of ES we designed describes effectively the ES process. In this section we do not intend to validate the model's relevance for a direct validation of ES systems evaluation. Indeed, we want to verify if the model effectively reflect the ES process.

Method

We performed a preliminary evaluation of the relevance of our model by comparing it to the actual behaviors of three information-seekers performing an ES task on the Discovery Hub[1] ES system, a Web application enabling users to explore various domains, such as history, art, politics, or geography. First, we asked to the participants their personal interests in order to propose personalized ES tasks. The tasks are: "*Learn new information about the history of free-jazz*" for the first participant; "*Discover new board games*" for the second one, and "*Learn new information about Senegal*" for the third one. Users' engagement is really important in the test of ES systems. It is this engagement, and the user' motivation to explore a topic, which we wanted to elicit in this test.

When the topic to be explored was agreed, the users were presented with an interactive demo of the Discovery Hub ES system they are going to use. Thanks to the demo, users learned how to use the system and its different features (filters features, explanation features…), and they did not waste time to discover the system when they will perform the search ES task. Therefore, they were more focused on the ES task.

The three participants explored their topic for twenty minutes on Discovery Hub. The search sessions were recorded with a screen recorder. After the test, there was a debriefing session: the participants watched the video of their search session and commented their choices, their actions, their thoughts, etc. These explanations were again screen-recorded (Figure 1). The records and their related comments were analyzed to assess if our ES model reflected the reality of user's exploration. The analysis consists in verifying the presence of the model's ES features in the users- ES activity. The analysis was performed by the designer of the model, by checking the presence of the exploratory search features in. the videos and the users' comments, using indicators of this presence. For example when the user is scanning the result list and says "I briefly explore the results list, just to have an idea of the retrieved results", the identified feature is *H.*

[1] http://discoveryhub.co/

Previous Features	Features	Next features
NA	**A**	B;J
A;F	**B**	G;H;I;J
D;E;I	**C**	D;E;F;G;H;J
E;I	**D**	C;F;G;J
G;H;I	**E**	C;D;F;G;J
C;D;E;H;I	**F**	B;H;I;J
B;D;E;H	**G**	E;H;I;J
B;F;G;I	**H**	E;F;G;I;J
B;F;G;H	**I**	C;D;E;F;H;J
All	**J**	**NA**

Table 2. Non exhaustive list of possible transitions in an exploratory search

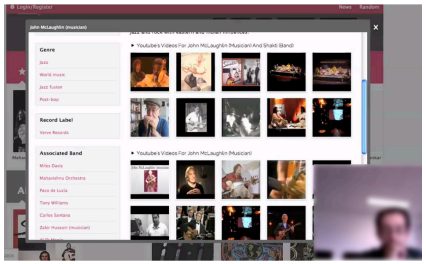

Figure 1. A participant commenting the screencast of his search session

Browsing results". Following this methodology, we reported the different chains of the different features the users used (e.g. $A \rightarrow B \rightarrow H \rightarrow I \rightarrow E \rightarrow G \rightarrow H \rightarrow \ldots \rightarrow J$) in their ES session.

Results: a completed model

The first main result of our analysis is that we indeed found the ES features of our model of ES in the search activity of the three participants. We can therefore say that our model can express the users' activity during an ES task. A second main result led us to complete our model with the notion of *transitions between ES features*. This second result is a specification of the transitions observed among the participants (see Table 2). In our model of ES, as well as in Ellis' model, there is no unique order between the features. The user follows her own search session pathway, according to her thoughts, her expertise in the field explored, the elements of information she encounters, and so on. Therefore, different orders are followed by the users when performing their ES session, and it is very informative to identify the transitions that exist between the features, as these transitions reflect the symbiotic interaction between the user and the system in the exploratory search process. This completed version of our model expresses the ES process with the possible transition offer a broader vision of what the ES process is. Indeed, this process is unpredictable and the list of the possible transition between the model's features highlights behaviors that we could not find with a state of the art, *i.e.* without empirical analysis. Furthermore, the ES behaviors reflected in these possible transitions are behaviors that ES systems should support, which means that our evaluation methods should provide elements which help and support their achievement.

Conclusion and Future Work

In this paper, we introduced an approximate model of exploratory search that we designed as a basis for a two evaluation methods for exploratory search systems. The model defines two main concepts: (1) *exploratory search features* (i.e., not strictly ordered search steps), and (2) transitions between these features. The notion of *transitions* have been added to the model after a preliminary validation following the observation of three information-seekers performing an exploratory search task on a specific system named Discovery Hub.

We want to use the model introduced in this paper as a basis for the elaboration of two evaluation methods of exploratory search systems. The first inspection method proposes a set of heuristics of ES which reflect the model. Thus, evaluators can use for them in the evaluation of their ES system without knowing anything about the model. The second method consists on user testing, with a procedure in line with the evaluation exposed here. It proposes a simplified version of the model for an easy use and an easy identification of the model's features in ES sessions on a given ES system.

For the HCI community the model offers a framework for a better understanding of this particular and unpredictable process of exploratory search. Additional evaluations of the model, following the same protocol, are scheduled with other exploratory search systems. These evaluations will offer the opportunity to discover new transitions and further validate the relevance of the model.

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A | Exploratory Search Characteristics	
1	*An evolving search process*
2	*Several one-off pinpoint searches*
3	*An evolving information need*
4	*Multiple targets/goals of search*
5	*Multiple possible answers*
6	*No expected exact answer*
7	*A serendipitous attitude*
8	*An open ended search activity which can occur over time*
9	*Context of search or goals*
10	*Multifaceted*
11	*Uncertainty is fluctuating*

B | Information Seeking Models Analysis				
ELLIS	BATES	KUHLTHAU	MARCHIONINI 95	MARCHIONINI 06
Yes (inferred)	Yes	No	Yes	Yes
No	Yes (inferred)	No	No	Yes
No	Yes	No	Yes	Yes
No	Yes	No	Yes	Yes (inferred)
Yes (inferred)	Yes	No	Yes	Yes (inferred)
Yes (inferred)	Yes	No	No	Yes (inferred)
No	Yes	No	Yes	Yes
No	No	No	No	Yes
Yes (inferred)	Yes (inferred)	Yes	Yes	Yes
No	No	No	Yes	No
No	No	Yes	No	No

Table 1. A) Characteristics of exploratory search. **B)** Information seeking models analysis. In this table, (1) *"Yes"* refers to a characteristic explicitly mentioned in the description provided by the author(s); or (2) *"Yes (inferred)"* refers to a characteristic which can be inferred from the description; or (3) *"No"* refers to an absent characteristic or a characteristic which cannot be inferred.

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