

Information seeking processes as temporal developments: comparison of stage-based and cyclic approaches

Reijo Savolainen

Faculty of Communication Sciences

FIN-33014 University of Tampere, Finland

Post-print version (October 2017), to appear in *Journal of the Association for Information Science and Technology* 69(2018):6, ISSN 2330-1643

Abstract

Drawing on the ideas of process philosophy, this study elaborates the nature of information seeking process by approaching them as temporal developments. To this end, a conceptual analysis was made by comparing key models which approach information seeking as stage-based and cyclic processes. The nature of such processes was scrutinized by devoting attention to two main aspects, i.e., the temporal order in which the constituents of information seeking appear during the process, and the changes occurring in the constituents. Stage-based approaches draw on linear time concept by conceptualizing such processes as sets of consecutive activities progressing toward a final point. Cyclic approaches conceptualize information seeking processes as sets of iterative activities which may be repeated. The findings suggest that stage-based and cyclic approaches should not be seen as opposite approaches; rather, they complement each other. However, cyclic models emphasizing the importance of feedback loops have gained more popularity in the modeling of Web searching in particular, while the interest in the development of stage-based approaches has decreased since the 1990s.

Introduction

Since the 1980s, researchers have developed a variety of models depicting how people identify, select, and access information sources (Case & Given 2016, pp. 141-175; Wilson, 2010). The totality of such activities is often referred to as “information seeking process” (White, 2016, pp. 105-109). Even though the phrase *information seeking process* is commonly used in information behavior research, its meaning has not been reflected in greater depth. What exactly are we talking about when we talk about information seeking as a *process*? This question is demanding because the word *process* denotes a generic concept which defies an exact definition. As there is no commonly agreed definition of this concept, we may start from the characterization provided by Merriam-Webster Dictionary and Thesaurus (2017c). It suggests that *process* is “series of actions, motions, or operations leading to some result” and “continuing natural or biological activity or function”. The above characterization suggests that the construct of process incorporates two fundamental dimensions. First, there is the dimension of substance of actions constitutive of processes. In the particular case of information seeking process, such actions (or activities) may include, for example, the selection of information sources and the evaluation of search results. Second, there is the temporal dimension indicating how such activities continue as series of actions and possibly change during the information seeking process.

The present study contributes to information behavior research by concentrating on the temporal dimension of information seeking processes. This focus was chosen because the temporal nature of information seeking is still an underexplored topic, despite the long-time interest in the issues of temporality within the field of information behavior research (Savolainen, 2006b). Since the 1990s, researchers have examined the processes of information retrieval (IR) occurring during individual search episodes (Belkin *et al.*, 1995; Spink, 1997). More recently, there is a growing interest in issues such as temporal representation of queries, temporal tagging, and event-based summarization (Alonso *et al.*, 2011; Joho, Jatowt & Blanco, 2015). In addition, there are studies examining web trails, i.e., temporally ordered sequences of items visited by searchers (White, 2016, p. 29). The length of such trails may vary, depending on whether the focus is placed on queries, browsing events or search sessions.

In the analysis of the temporal qualifiers of information seeking processes, two research approaches have been particularly influential. *Stage-based approaches* assume that such processes occur linearly in time by proceeding from a phase to another (e.g., Kuhlthau, 2004). In contrast, *cyclic approaches* propose that these processes are not entirely linear because information seekers can revisit previous stages (e.g., Marchionini, 1995). The present investigation elaborates further the above issues by making an in-depth conceptual analysis by comparing how the construct of *information seeking process* has been approached in the stage-based and cyclic models of information seeking. However, as the findings of the study suggest, the stage-based and cyclic models should not be seen as opposite approaches because the former characterizes information seeking processes at macro level, while the latter concentrates on micro level phenomena.

Stage-based and cyclic approaches were chosen for the study because they are most widely used in the modeling of information seeking, thus providing a rich variety of research material. More importantly, however, the comparison of these approaches enables the analysis of two major aspects of temporality constitutive of information seeking processes. First, as explained in more detail in the next section, *temporal order* is a major qualifier of such processes because it indicates how the activities constitutive of processes continue as series of actions. More specifically, temporal order indicates how the constituents of information seeking follow each other during the process. For example, the constituent of defining an information need may appear first, followed by the constituents of identifying potentially relevant information sources and accessing them by calling a colleague and visiting a website. Another temporal aspect of interest in the present study is the *change* occurring in such constituents during the information seeking process. For example, people may prefer human sources in the initial stage of the information seeking process while sources of other types may replace them when the process goes on. Drawing on the above ideas, the overall goal of the present study is elaborate the picture of information seeking processes as temporally sensitive phenomena by comparing how they are approached from stage-based and cyclic viewpoints.

This remainder of the article is structured as follows. To give background, the next section elucidates the main concepts of the study and characterizes the temporal qualifiers of information seeking. Thereafter, the research questions and methodology will be specified, followed by the presentation of findings. The final section discusses the findings and draws conclusions of their significance.

Background

Process and Its Temporal Qualifiers

Process is a multi-faceted phenomenon that has been subject to philosophical investigation since times of Ancient Greece. The Greek theoretician Heraclitus of Ephesus is commonly recognized as the founder of *process philosophy*. He described the inherently dynamic nature of being by aphorisms such as “everything flows” and “no man ever steps in the same river twice, for it’s not the same river and he’s not the same man” (Graham, 2015). Process philosophy opposes *substance metaphysics*, which claims that the primary units of reality (called “substances”) must be static (Rescher, 2012). In contrast, process philosophers analyze becoming and what is occurring as well as ways of occurring. Since the 19th century, the ideas of process philosophy have been elaborated from diverse viewpoints. For example, William James and John Dewey developed a process-based pragmatist metaphysics – an approach which influenced the development of the Information Search Process (ISP) model proposed by Kuhlthau (1991). Dewey holds that all existents are events and that the process-character of being is rendered meaningful by human agents’ practical and theoretical interpretations of an ongoing situation (Rescher, 2012).

It is also a key characteristic of process philosophy that it approaches processes as temporal developments. To this end, processes are approached as temporally structured sequences of stages of an occurrence, with each such stage being qualitatively different from any other (Rescher, 2012). What holds for all dynamic entities labeled “processes” is that they are connected not only to temporal extension but also to the directionality or passage of time. Philosophers have debated these issues for centuries, with no definitive answers (Callender, 2011). Nevertheless, there is general agreement among philosophers that time is continuous; we do not experience it as starting and stopping at random. It is also widely agreed that time has an intrinsic direction or order in that events progress from past to present to future: the arrow of time flies only one direction. However, despite the predominance of the linear time conception, time can be conceived as a cyclic phenomenon, based on repetition apparent in the natural world. Day/night cycle regulates our lives; cyclical patterns are also suggested by longer cycles such as summer, fall, winter and spring. This is evident if the above patterns are examined at an abstract level. However, looking at a particular season or day one may argue that they are not cyclical because they do not reoccur in a similar fashion; each day (e.g., Thursday, 27 July 2017) and each season (e.g., summer 2017) are unique. This view provides support for Heraclitus’s dictum that “no man ever steps in the same river twice”.

As noted above, processes as temporal developments are usually approached from the viewpoint of stages (Rescher, 2012). Generally defined, the concept of *stage* refers to “a period or step in a process, activity, or development” (Merriam-Webster Dictionary and Thesaurus, 2017d). The idea of the existence of stages draws strongly on the linear time conception suggesting that processes occur in chronological sequences and that sequences can be interpreted in terms of stages. A closely related concept is *phase*, which refers to “a part or step in a process: one part in a series of related events or actions” (Merriam-Webster Dictionary and Thesaurus, 2017b). In information behavior research, the above terms are often used interchangeably, even though the term *stage* seems to be more popular (e.g., Kuhlthau, 2004; Wilson, 1999). In the present study, the term *stage* will be preferred due to its popularity among researchers, and the term *phase* will be used synonymous to *stage*.

However, *stage* is not the only temporal viewpoint to processes because stages or phases can occur repeatedly, resulting in a *cycle*. In general, *cycle* can be defined as “a repeating series of events or actions” (Merriam-Webster Dictionary and Thesaurus, 2017a). Each repetition of actions forms an *iteration*, and the results of one iteration can be used as the starting point for the next iteration. In the models of information behavior, the iteration is indicated by feedback loops (e.g., Marchionini, 1995; Meho & Tibbo, 2003). Different from the construct of *cycle*, *iteration* is not approached as a temporal qualifier because it refers to the ways in which the activities are repeated in practice by revisiting information sources, for example. Even though cycles are constituted by stages or phases, *cycle* can be interpreted as a temporal approach of its own because it is necessary for the understanding of the nature of recurring activities constitutive of processes. However, cyclic approaches do not suggest that the direction of time could be reversed in an absolute sense, for example, by taking a “time travel” back to a Web search session completed two months ago. Even though identical search terms would be used in order to repeat the search, it is de facto a new search. The iteration occurs in a new moment of time and the search can provide novel results, thanks to the availability of recently downloaded articles on the topic. Moreover, the user may evaluate the search results differently, due to the use of more specific relevance criteria. Therefore, the idea of the cyclic approach is well in accord with Heraclitus’s aphorism proposing that “no man ever steps in the same river twice, for it’s not the same river and he’s not the same man”.

Time as Contextual Factor of Information Seeking

Information seeking is a deeply contextual phenomenon that is affected by a myriad of cognitive, social, cultural and spatial factors such as the requirements of work task performance, the nature of contact networks and the accessibility of information sources (for an overview, see Courtright, 2007; Johnson, 2003). Time is an important contextual and situational factor of information seeking and information behavior. Drawing on an extensive literature review, Savolainen (2006b) identified three major approaches to time as a factor of information seeking. First, time can be conceptualized as a fundamental attribute of situation or context of information seeking. For example, Dervin (1997, pp. 17-20) suggested that reality is discontinuous, gap filled, and changeable across time space, and it is accessible only – and always incompletely – in context, in specific historicized moments in time space, and in spatial and temporal confluence of people, settings, activities, and events. Thus, the context of information seeking is something that changes over time; due to temporality, context is emergent and fluid. Ultimately, temporal factors become real as constitutive elements of contexts only through human practices. Second, time can be approached as a qualifier of access to information (Savolainen, 2006b). This approach emphasizes the fact that time is a scarce resource and that lack of time tends to be a frequent barrier to information seeking. Temporal qualifiers may also be actualized in the context of information overload, when too much information has to be interpreted within too narrow a time frame.

Third, and most importantly from the perspective of the present study, time can be approached as an indicator of the information seeking process (Savolainen, 2006b). From this perspective, temporal factors affecting the selection process can be illuminated by studying the order in which people would access information sources if they were to experience a specific kind of information need in the future. For example, Case, Johnson, Andrews, Allard, and Kelly (2004, pp. 663-664) found that people seeking genetics information were most likely first to turn to the Internet for information about genetics, disease, and testing, second to a medical doctor, third to a public library, and fourth to a family member. Time as an indicator of the information seeking process has also been conceptualized in stage-based models for information seeking (e.g., Kuhlthau, 1991). Information seeking models implying temporal factors in the form of feedback loops have become more frequent since the 1990s (e.g., Leckie, Pettigrew & Sylvain, 1996; Meho & Tibbo, 2003). Drawing on the empirical findings of a study focusing on interdisciplinary researchers Foster (2004) claimed that information seeking is not bound chronologically or by problem stage. Instead, information seeking is cumulative, reiterative, holistic, and context bound and characteristic of it are concurrent, continuous, cumulative, and looped cycles occurring throughout the research project. The present study elaborates further the above picture of time as a contextual factor of information seeking by examining how information

seeking process has been modeled as a representation of events or stages that occur over time in a linear, iterative or cyclical sequence.

Research Design

Drawing on the ideas of process philosophy, the present study approaches information seeking processes as temporal developments (Rescher, 2012). The above issue will be examined by concentrating on how temporal qualifiers as contextual factors determine the nature of information seeking as staged or cyclical processes. To this end, the main attention will be devoted to conceptualizations of information seeking processes presented in the key models of information seeking. Following White's (2016, pp. 105-109) definition, information seeking process models are generally understood as frameworks depicting "information searching as a multi-stage process through which people transition during the search process, with backtracking and iteration as required". It is further assumed that the fundamental features of information seeking processes as temporal developments can be captured by focusing on two major aspects: (i) the continuation of the process indicated by the temporal order in which the constituents of information seeking appear, and (ii) the changes occurring in such constituents. These aspects will be analyzed by comparing the stage-based and cyclic approaches. To this end, the present study addresses the following research questions:

- RQ1. In terms of the temporal order in which the constituents of information seeking processes appear, how have researchers approached the continuation of such processes from the stage-based and cyclic viewpoints?
- RQ2. In which ways have researchers approached the changes occurring in the constituents of information seeking processes by drawing on the stage-based and cyclic viewpoints?

To strengthen the focus of the study, no attention will be devoted to other contextual factors influencing the information seeking process. Such factors include, for example, spatial qualifiers like physical distance to an information source (Savolainen, 2006a) and the urgency of work task performance (e.g., Xie, 2009). Furthermore, other constructs relevant for the study of temporal qualifiers of information seeking processes will be excluded from the study. These constructs include, for example, *situation* and *episode* which are relevant for the study of information seeking taking place in individual search sessions or successive searches (e.g., Lin & Belkin, 2005, Spink, 1997). It is evident that the examination of the above issues would require a separate study.

Method

The research material was identified by searching EBSCOhost Academic Search Premier, Google Scholar, LISA and Scopus. The keywords used in the searches included, for example, information retrieval, information search, information searching, information seeking, process, time, and temporal. Moreover, review articles and book chapters focusing on this topic were scrutinized (e.g., Case & Given, 2016, pp. 141-175; Wilson, 2010). Drawing on Wilson's (2000, pp. 49-50) nested model of information behavior, *information seeking* was defined as subset of human information behavior. Information seeking refers to a set of activities employed in discovering and accessing information resources (both humans and systems) in response to goals and intentions. *Information searching* was defined as subset of information seeking - a micro-level behavior - referring to the purposive actions involved in interacting with an information search system, including IR systems and the World Wide Web (WWW). The searches resulted in the identification of 136 articles, book chapters and conference papers reviewing the processes of information seeking, searching and retrieval. No date range was used in the searches because an attempt was made to identify all relevant studies conceptualizing stage-based and cyclic approaches to information seeking processes. The initial sample of 136 items contained studies published within the period of 1976 until 2017. Most of these studies appeared to be redundant because they mainly described the features of models developed by Kuhlthau (1991) and Wilson (1997), for example. Finally, a sample of 32 investigations was chosen for conceptual analysis by two main criteria. First, these studies explicitly characterize information seeking processes. Second, these investigations provide relevant material for the analysis of temporal qualifiers of such processes.

The documents chosen for the analysis were scrutinized by means of conceptual analysis. This method can be defined as an approach that treats the components of the research objects, e.g., information seeking process as classes of objects, events, properties, or relationships (Furner, 2004). Conceptual analysis involves defining the meaning of a given component by identifying and specifying the contexts in which it is classified under the concept in question. More specifically, the documents were analyzed by devoting attention to how researchers have characterized the aspects of temporal order and change from the stage-based and cyclic viewpoints. The aspect of temporal order was identified from the research material by examining how researchers have described and explained the sequential occurrence of the constituents of information seeking, for example, the order in which the stages of information seeking occur (Kuhlthau, 1991), or the order in which browsing and searching reoccur within diverse stages (e.g., Meho & Tibbo, 2003). The aspect of change was

identified by devoting attention to the ways in which researchers have characterized the formation or alteration of the constituents of information seeking process. Such changes include, for example, alteration of search tactics and strategies (Xie, 2009) and redefinition of information problems (Marchionini, 1995). The main focus was placed on classic models of information seeking (Ellis, 1989; Kuhlthau, 1991; Marchionini, 1995; Wilson, 1997) because they provided original and most specific characterizations of the above issues. It appeared that even though more recent models (e.g., Foster, 2004; Joseph *et al.*, 2013; Moral *et al.*, 2017, Wilson, 2017) insightfully make use of the ideas presented in the classic frameworks, these studies do not add much new to the picture of information seeking processes as temporal developments.

Relevant text portions (paragraphs and sentences) pertaining to the research topic were first identified. This material was then read several times in order to identify individual characterizations of the components and their relationships. More specifically, the texts chosen for analysis were subjected to open coding to identify the categories describing the information seeking processes. All *coding was conducted by the* present author, due to the unavailability of second experts. Because the study is conceptual in nature and thus does not aim at statistically representative generalizations, the requirement of the consensus on coding decisions based on interrater reliability can be compromised without endangering the reliability of the study. According to Miles and Huberman (1994, p. 64), check-coding the same data is useful for the lone researcher, provided that code–recode consistencies are at least 90%. Following this guideline, check-coding was repeated, and the initial coding was carefully refined until there were no anomalies. Categories identified include, for example, stage of information seeking, iteration of information searching, and change in information searching process. However, the study approach was kept flexible enough to allow for other categories to emerge. However, no additional categories describing the temporal qualities of information seeking processes were found. The conceptual analysis was based on the identification of similarities and differences between various characterizations of the diverse categories. This was continued until there were no new ideas arising from the comparison.

Findings

Stage-based Approaches

The main point of departure of the stage-based approaches is that information seeking processes can be conceptualized as a set of consecutive steps or phases within which the activities constitutive of

such processes are accomplished. More specifically, it is assumed that the information seeking process is comprised by constituents such as an individual's source preferences and his or her ways to identify information sources. These constituents appear in a certain order characteristic of diverse temporal sub-contexts labeled as stages or phases. Stage-based approaches assume that the phases can be identified quite exactly by determining the starting and final points of the information seeking process, and that the process occurring between these points can be further compartmentalized into diverse phases. Finally, it is assumed that the constituents of information seeking undergo changes when the information seeker moves from a stage to another.

So far, the most sophisticated view on the stage-based approach is provided by Kuhlthau's (1991; 2004) Information Search Process (ISP) model. Based on longitudinal studies of information seeking among diverse groups such as high school students and library users, the ISP model identifies six task-specific stages: initiation, selection, exploration, formulation, collection and presentation. The model also specifies three realms constitutive of components of task-related information seeking process: the affective (feelings), the cognitive (thoughts), and the (physical) actions common to each stage (Kuhlthau, 1991, pp. 366-368).

The ISP model conceptualizes information seeking as a continuous process during which its components appear in a certain temporal order characteristic of each stage. In the above model, this order is described as a left-to-right progression (Beheshti *et al.*, 2015, p. 943). For example, cognitive constituents (thoughts) typical to the initial stage include comprehending task and relating prior experience, while in mid stages, for example, exploration, thoughts revolve around identifying several possible focuses. In the final stage (presentation), cognitive constituents include considering time limit, for example. The affective constituents (feelings) also appear in certain order. At the initial stage, apprehension at work ahead is dominating, while at the mid stages, for example, exploration, feelings such as confusion and doubt are commonly experienced. In the final stage, sense of relief and satisfaction tend to be general if the task has been performed successfully. Overall, during the information seeking process, the cognitive and affective constituents tend to develop in a positive direction. The searcher's thoughts become clearer and the emotions experienced during the process tend to turn from negative to positive.

In the explication of the ISP model, Kuhlthau devotes the main attention to the nature of affective and cognitive realms characteristic of each stage. In comparison, the characterization of the (physical) actions occupies a minor role; in this regard, the processual nature of information seeking remains

implicit. To describe the nature of such actions, Kuhlthau (2004, pp. 44-50) identifies a set of information sources and channels deemed most useful for the accomplishment of learning tasks in diverse stages of the process. For example, talking with others and browsing library collection may provide relevant information at the initial stage, while taking detailed notes with bibliographic citations can offer pertinent information at the stage of collection. Nevertheless, the ISP model largely remains silent about the temporal nature of the stage-based approach. The model approaches information seeking as an ongoing process rather than a single event by emphasizing the viewpoint of constructive process of information seeking (Kuhlthau, 1999, pp. 13-15).

On the other hand, the empirical findings of a longitudinal follow-up survey among students indicated that the information search process is not always linear. Although the students perceived the process as moving from general information to specific, their descriptions of searching revealed more of a spiral of thoughts building through the information encountered rather than a neat step-by-step progression (Kuhlthau, 2004, p. 79). Therefore, the requirements of linearity are relaxed because the ISP model represents “more of a metaphor for common experience in the search process than a prescription or a precise replication of individual experience” (Kuhlthau (2004, p. 93). Although the sequence of constructive experience described accurately emulates the search process, the pace of the process may vary from individual to individual and search to search. Thus, Kuhlthau (2004, p. 94) concedes that the process may incorporate cyclic features, with stages recurring in a persistent quest for decreased uncertainty and increased understanding.

The ideas of the stage-based approach have also been used in models in which components obtained from other frameworks are combined in a novel way in order to create a sequential approach to information seeking process. Inspired by Kuhlthau’s ISP model, Wilson (1999, p. 256) proposed a framework in which the generic information-seeking characteristics identified by Ellis (1989) and Ellis, Cox and Hall (1993) were presented as a constellation of consecutive components. These characteristics include starting, browsing, chaining, monitoring, differentiating, extracting, verifying and ending. Wilson’s approach is against Ellis’s (1989) original idea that the above characteristics should not be interpreted as constituents appearing in a certain order during the information seeking process. Importantly, Wilson (1999, p. 256) proposed that despite different terminology, the models developed by Kuhlthau and Ellis could be brought together because they share some fundamental elements. For example, Kuhlthau’s categories of exploration and collection can be associated with Ellis’s chaining, browsing and monitoring, while presentation is equivalent to verifying and ending.

Gathering information is closely related to extracting and verifying, while search closure is equivalent to verifying and ending in the extended model proposed by Ellis and his associates (1993).

Wilson's (1999) model is quasi-staged in nature because the characteristics of browsing, chaining and monitoring can appear in a parallel fashion and simultaneously. Wilson (1999, p. 254) reminded that except of the temporal starting and ending points, other characteristics may be initiated in different sequences at different times in the overall search process. Thus, the requirements of stage-based models suggesting a strictly defined sequence of individual components are relaxed. As the integrated model is very general in nature, based on the matching of similar features of components identified by Kuhlthau and Ellis, Wilson's (1999) framework remains silent about how the constituents of the information seeking process would change, as the individual moves from one stage to another.

More recently, in a study examining information searching among students writing their research proposals, Vakkari (2001) integrated Kuhlthau's six stages into a three-stage model. *The pre-focus* stage incorporates initiation, selection and exploration, followed by the stage of *formulation*, while the *post-focus* stage includes collection and presentation. Even though Vakkari condensed the temporal scale, his empirical findings are highly relevant as an explication of the changes occurring in the constituents of the information seeking process. It appeared that the students changed their search tactics corresponding to their changes of stages. In particular, as users moved forward through stages, they increased their use of search formulation tactics (e.g., intersect, vary, and parallel) and application of conceptual search tactics, and decreased the employment of operational tactics. Similarly, Xie (2009) found that stages of tasks play a crucial role in influencing users' application of information seeking strategies. While users focused on exploring different topics at the pre-focus stage, at the formation stage they concentrated more on how to formulate the query to represent their topics. During the post-focus stage, they applied the pearl-growing strategies, checked with human resources about their search results from the formation stage, as well as searched for different formats of documents.

Cyclic Approaches

Different from the stage-based viewpoint, cyclic approaches allow a more flexible characterization of the temporal features of the information seeking process. It is not sliced into consecutive stages that the information seeker goes through only once and in a certain order. The key idea of cyclic

approaches is that one or more activities constitutive of information seeking process can reoccur. Thus, cyclic approaches depict opportunities for returning back during the information seeking process: an earlier stage (or stages) can be repeated, and the constituents of the information seeking process can appear in varying order during individual cycles. Some of the constituents can also occur simultaneously.

There are diverse versions of the cyclic approaches, ranging from general characterizations to detailed specifications of individual constituents of information searching processes. A general level cyclic approach to information seeking processes is exemplified by Wilson's (1997, pp. 569-570) general model of information behavior. The model suggests that information seeking behavior is triggered by a context-specific information need. Once initiated, information seeking is driven by a combination of activating mechanisms such as active coping strategies and positive self-efficacy beliefs. Information seeking behavior may appear in four ideal typical major modes, i.e. passive attention, passive search, active search and ongoing search. The constellation of these modes is connected to the component of context of information need by the construct of *information processing and use* which is characterized as a "necessary part of the feedback loop, if information needs are to be satisfied" (Wilson, 1999, p. 256). As the nature of the constituent of "information processing and use" is not specified in greater detail, it remains unclear how such processing would indicate changes occurring in active search and ongoing search, for example.

The temporal issues are reviewed in greater detail in Meho and Tibbo's (2003) study where they presented a revised version of Ellis's (1989) classic model of information seeking characteristics. Based on an empirical study among social scientists, Meho and Tibbo (2003) enhanced the original model by adding four new characteristics: synthesizing, writing, networking, and information managing. The most radical change derives from the incorporation of four stages of information seeking: *searching*, *accessing*, *processing*, and *ending* (Meho & Tibbo, 2003, p. 583). In the revised model, these four components represent diverse stages of iterative cycles, while the constituents of information seeking process include a variety of activities such as starting, chaining, browsing and monitoring.

Different Wilson's (1997) cyclic framework, the model proposed by Meho and Tibbo does not specify a definite starting point of information seeking processes such as "context of information need". However, we may think that most information seeking processes are initiated at the stage of *searching*. It stands for the period where the identification of potentially relevant materials is initiated.

The *accessing* stage can be defined as the bridge between the searching stage and the processing stage. The *processing* stage is where the synthesizing and analyzing of the information gathered takes place. Thus, different from the above stages, it primarily deals with information use. Finally, the *ending* stage marks the closure of information seeking. Meho and Tibbo (2003, p. 584) showed that in each of the first three stages, i.e., searching, accessing, and processing, a number of information-seeking characteristics can take place. For example, during the searching stage, researchers may use starting, chaining, browsing, monitoring, differentiating, extracting, and networking activities, while during the processing stage, researchers might use chaining, extracting, differentiating, verifying, and information-managing activities. Within a stage, individual characteristics such as chaining, browsing and differentiating can reoccur in varying order. On the other hand, individual constituents, for example, chaining and differentiating can occur within two separate stages, that is, searching and processing.

Thus, different from Wilson's (1999) quasi-staged model, Meho and Tibbo adopted a more flexible approach. The combination of features and stages resulted in a framework that is hospitable to the modeling of the cyclic nature of information seeking. The model provides a nuanced picture of the nature of cyclic processes exhibiting the ways in which people may flexibly engage in diverse information-seeking activities originally identified by Ellis (1989). Overall, in Meho and Tibbo's model, the main attention is devoted to the order in which diverse constituents may occur within or across stages, while the framework remains unclear about how the constituents such as browsing change during the iterative cycles.

So far, perhaps the most sophisticated cyclic model depicting the processes of information searching and retrieval is proposed by Marchionini (1995). Different from the above models characterizing macro level constituents of information seeking processes, e.g., activities such as browsing and chaining, Marchionini focused on micro level constituents such as *define problem* and *execute query*, which he labeled as *subprocesses*. This construct occupies a double role because the subprocesses not only refer to a set of activities constitutive of information seeking but also represent individual stages of this process. In Marchionini's (1995) model, eight stages of information seeking are presented as a left-to-right progression similar to Kuhlthau's (2004) ISP framework. However, there is a number of feedback loops indicated by right-to-left arrows. This makes the model quite complicated. As Wilson (2017, p. 147) points out, the sheer number of back-arrows presents a challenge "to find a pair of boxes that are *not* connected by a back-arrow". Marchionini's (1995, pp. 49-57) model suggests that information seeking process begins with the recognition and acceptance of an

information problem and continues until the problem is resolved or abandoned. The process can proceed along parallel lines of progress and take advantage of opportunities arising from intermediate or random results.

At the initial stage, the individual recognizes and accepts (or suppresses) an information problem. If the information seeker judges the situation appropriate and accepts the problem, he or she moves to the second stage where he or she defines and understands the problem. Problem definition is a critical step in the information seeking process, and this subprocess remains active as long as information seeking progresses. At the third stage, the activity concentrates on choosing an electronic search system, even though the label of this phase, i.e. "select source" suggests a broader repertoire of activities characteristic of this phase because the users can consult librarians, for example. The process continues to stage 4 where the information seeker formulates a query by matching understanding of the task with the system selected. In the fifth stage, the user executes the search, while in the sixth stage, he or she examines the results. In the next stage, information will be extracted from the information objects found. Thus, there is an inextricable relationship between judging information relevant and extracting the relevant information for all or part of the problem solution. In the final stage, the user reflects or stops the search.

Marchionini's model reveals the potentially complex structure of information seeking process which is frequently iterative and finely interweaved. Moreover, there may be simultaneous activities when the user reflects the search results (stage 8) and considers the redefinition of the information problem (stage 2). The model suggests that some of the feedback loops are more probable than others. For example, it would be more probable that the examination of search results (stage 6) is followed by query reformulation by returning back to stage 4, as compared to the case in which the information seeker selects a search system (stage 3) and then redefines the information problem (stage 2). Different from the models developed by Wilson (1999) and Meho and Tibbo (2003), Marchionini's framework describes in greater depth information seeking as a set of subprocesses that can proceed both iteratively and simultaneously. The main changes occurring during the iterations deal with the definition of the problem giving rise to information seeking, formulation and reformulation of queries and relevance judgments.

Discussion

Based on conceptual analysis, the present study filled gaps in research by scrutinizing the nature of information seeking processes as temporal developments. They were examined from the stage-based and cyclic viewpoints by focusing on two major aspects of processes. The continuation of processes was approached in terms of the temporal order in which the constituents of information seeking appear during the process. In addition, it was examined how researchers have approached the changes occurring in the constituents of information seeking processes. The main findings are summarized in Table 1.

Table 1. Summary of the main findings.

	Temporal approach	
	Stage-based	Cyclic
Main constituents of the information seeking process	Cognitive elements (thoughts), affective elements (feelings) and (physical) actions (Kuhlthau, 2004)	Passive attention, passive search, active search and ongoing search as modes of information seeking (Wilson, 1997)
	Generic characteristics of information seeking defined by Ellis (1989), e.g., starting, chaining, browsing and ending as a constellation of consecutive components (proposed by Wilson, 1999)	Generic characteristics of information seeking defined by Ellis (1989), e.g., starting, chaining, browsing and ending (proposed by Meho & Tibbo, 2003)
	Search tactics (Vakkari, 2001) and search strategies (Xie, 2009)	Subprocesses of information seeking such as definition of information problem, choosing a search system and query execution (Marchionini, 1995)
Temporal order of the constituents of the information seeking process	Sequential occurrence of diverse constituents characteristic of a stage. For example, talking with others (stage 1), using reference collection (stage 2), taking notes on facts and ideas (stage 3) ... using library to collect pertinent information (stage 5) (Kuhlthau, 2004)	During the iterative cycles, individual constituents, for example, browsing, chaining and differentiating can reoccur within one or two stages in varying order (Meho & Tibbo, 2003)
		Individual, stage-specific constituents such as evaluation of search results (stage 6) and redefinition of information problem (stage 2) can occur simultaneously (Marchionini, 1995)
Changes occurring in the constituents of	Gradual formation of the constellation of affective and cognitive elements and (physical)	Redefinition of information problems, query reformulation and re-evaluation of search results (Marchionini, 1995)

the information seeking process actions indicating one's source preferences (Kuhlthau, 2004)
Alteration of search tactics and strategies (Vakkari, 2001; Xie, 2009)

Stage-based approaches conceptualize information seeking as a step-wise process which progresses linearly from a starting point to search closure. The ISP model exemplifies how the constituents of information seeking process change when cognitive, affective and conative realms undergo mutual changes, combined with the alterations in source preferences. Vakkari (2001) and Xie (2009) showed how the changes occurring in the constituents of information seeking can be described in more detail by comparing search tactics and strategies used in the pre-focus, formation and post-focus stages. Somewhat paradoxically, Wilson's (1999) attempt to marry the constituents of the ISP model and Ellis's (1989) generic characteristics of information seeking did not result in the elaboration of the picture of the information seeking process; rather, the integrated model revealed the limitations of the stage-based approaches. Nevertheless, stage-based approaches are helpful in that they enable an overview of information seeking processes particularly in cases in which they span over a longer period of time. Moreover, stage-based approaches are intuitively appealing because they help to structure how the information seeking process proceeds from a beginning through intermediate phases to an end.

Stage-based and cyclic approaches resemble each other in that they draw on the identification of diverse phases through which the information seeking processes move on. Both approaches have also made use of Ellis's generic characteristics by rethinking their role as constituents of the information seeking process. Even though cyclic approaches share the features of stage-based viewpoints in that some constituents, for example, recognition of information problem (Marchionini, 1995) or starting (Meho & Tibbo, 2003) appear first and the information seeking process terminates with activities such as "stop" (Marchionini, 1995) and "ending" (Meho & Tibbo, 2003), cyclic models break the strict linearity by means of feedback loops indicating the reoccurrence of individual activities. These models suggest that individual constituents can reoccur in varying order or simultaneously within one or two stages.

The conceptual analysis revealed that stage-based and cyclic approaches differ most clearly with regard to the temporal order in which the activities constitutive of information seeking process take place. Stage-based approaches such as the ISP model suggest a relatively fixed order from the initial

to the final phase. As the cyclic approaches allow the characterization of repetitive and simultaneous activities, these frameworks provide a more flexible approach to the study of the complex phenomena of information seeking processes. Overall, the main strength of cyclic approaches can be found in the sophisticated conceptualization of the temporal order of the constituents. However, the characterizations of changes occurring during the information seeking processes tend to remain at a general level in the cyclic models reviewed in the present study. Marchionini's (1995) framework is most informative in this regard because it characterizes the subprocesses dealing with the redefinition of information problems, query reformulation and re-examination of the search results.

Although stage-based and cyclic models provide different perspectives on the conceptualization of the information seeking process, they should not be seen as opposite approaches. Rather, they complement each other in that stage-based models characterize such processes at the macro level by devoting attention to multiple episodes of information seeking, while the cyclic models concentrate on the micro level and one episode of information seeking process. For example, Kuhlthau's (1991) ISP model approaches information seeking processes at the macro level by emphasizing the importance of stages. However, individual stages such as *exploration* and *formulation* can occur more than once and thus incorporate multiple episodes of information seeking. Even though Kuhlthau (1991; 2004) does not discuss this issue in greater depth, we may argue that the ISP model potentially incorporates iterative or even cyclical features. Cyclic models such as the framework proposed by Marchionini (1995) focus on micro level phenomena by emphasizing the significance of individual episodes of information seeking. On the other hand, models such as these could cover stages of information seeking as well, as exemplified by the categories of *problem definition*, *source selection* and *query formulation* in Marchionini's (1995) model.

Even though cyclic approaches have gained popularity in the modeling of information seeking, they have limited value in the analysis of situation-specific processes of information searching and retrieval. For example, the berrypicking model developed by Bates (1989) describes information seeking as a process taking place during search episodes. Within such temporal contexts, the individual picks pieces of information a bit at a time. Even though the evolving search process appears as a trail of cognitive and physical actions executed sequentially, proceeding from a tentative query to search closure, berrypicking cannot be classified as an example of a cyclic or stage-based approach. This is because the temporal order in which diverse sources are identified, accessed and used during the search process is not explained by referring to a stage of problem solving, for example; berrypicking is guided by the opportunities provided by an information environment. On the other

hand, the above model cannot be regarded as an example the cyclic approach because berrypicking activities occurring during a search episode may not be repeated in later situations. Therefore, the berrypicking processes model might be best examined from the viewpoint of situational approaches which place the main emphasis on activities occurring within a short period of time, for example, a Web search session (Pharo & Järvelin, 2004).

Given the inherent limitations of the stage-based approaches, cyclic viewpoints hold more potential for the modeling of the complex and dynamic features of information seeking processes. This potential may be enhanced further by combining the strongest aspects of cyclic and situational approaches. This notion is important since some of the information searching or micro models (e.g., Marchionini, 1995) can fall under the category of interactive information searching models and thus apply to web searching. In interactive searching occurring in electronic environments, users are likely to perform several iterations of the process before terminating the session (Toms, 2002, p. 857). Moreover, the user may recycle in multiple, nonlinear ways through category selection, cues, and extraction. This process can be viewed as a series of state transitions in which each state represents the interests of the user at that particular moment in time. Thus, the same set of items could be presented to the user, but different choices might be selected at different times. Recent studies characterizing the nature of interactive searching have confirmed the above ideas about the temporally sensitive nature of information seeking processes identified in the analysis of Web searching trails, for example (White, 2016). As the state of the user changes with time, a single instance is unlikely ever to be the same for the same person or for different people. Ultimately, these assumptions are in line with Heraclitus's process philosophical views suggesting that an information seeker never steps in the same "information river" twice, for it's not the same river and he's not the same man.

Conclusion

The present investigation elaborated the picture of information seeking process as temporal developments. The study provides three main contributions to information behavior research. First, the findings specify the nature of information seeking process by identifying two fundamental aspects making such processes intelligible. The aspect of temporal order indicates how the process moves on as a constellation of diverse constituents. The aspect of change indicates how the constituents undergo alterations during the process. Second, the study demonstrated that the above aspects have been conceptualized differently from the stage-based and cyclic viewpoints. Stage-based approaches view

information seeking processes as a linearly progressing constellation of activities, while cyclic approaches conceptualize these processes more flexibly as a set of iterative, back and forth transitions occurring within and across diverse stages. Third, the findings highlight that cyclic models emphasizing the importance of feedback loops have gained more popularity, while the interest in the development of stage-based approaches has decreased since the 1990s. This conclusion is supported by a recent study conducted by Moral and his associates (2017). They claim that the processes of information seeking cannot be perceived as a strictly linear process where a set of sequential tasks are performed to fulfill the information need. Instead, information seeking must be described as iterative, partly simultaneous and sometimes situation-specific processes with a great complexity.

To examine the nature of information seeking processes in greater depth, there is a need for conceptual and empirical investigations looking at the temporal qualifiers of information searching and retrieval, in connection to the analysis of their substance. Studies such as these may open possibilities to integrate both stage-based approach and cyclic approach into one temporal framework that covers both macro and micro level of information seeking process. The present study is limited in that it focuses on five classic models of information seeking. Moreover, as the models reviewed in the present study mainly deal with active and purposive information seeking, the picture of information seeking processes should be complemented by examining non-purposive modes of information acquisition such as serendipitous information encountering (Agarwal, 2015; Erdelez, 2005). Broadening the research perspective beyond the models of active information seeking may deepen our understanding about the temporal qualifiers of information behavior - a perennial issue in information science.

Acknowledgements

I would like to thank anonymous reviewers for insightful suggestions and constructive *feedback that greatly helped* to improve the manuscript.

References

Agarwal, N.K. (2015). Towards a definition of serendipity in information behaviour. *Information Research* 20(3). Retrieved from <http://InformationR.net/ir/20-3/pape5674.html>

Alonso, O., Baeza-Yates, R., Strötgen, J., & Gertz, M. (2011). Temporal information retrieval: challenges and opportunities. In *Proceedings of the 1st International Temporal Web Analytics*

Workshop (TAW 2011), March 28, 2011, Hyderabad, India (pp. 1-8). Retrieved from <http://ceur-ws.org/Vol-707/TAW2011-paper1.pdf>

Bates, M.J. (1989). The design of browsing and berrypicking techniques for the online search interface. *Online Review*, 13(5), 407-424.

Beheshti, J., Cole, C., Abuhimed, D., & Lamourex, I. (2015). Tracking middle school students' information behavior via Kuhlthau's ISP model: temporality. *Journal of the Association for Information Science and Technology*, 66(5), 943-960.

Belkin, N.J., Cool, C., Stein, A., & Thiel, U. (1995). Cases, scripts, and information-seeking strategies: on the design of interactive information retrieval systems. *Expert Systems with Applications*, 9(3), 379-395.

Callender, C. (2011). Introduction. In *The Oxford handbook of philosophy of time* (pp. 1-10). Oxford, UK: Oxford University Press.

Case, D.O., & Given L.M. (2016). *Looking for information. A survey of research on information seeking, needs and behavior*. 4th ed. Bingley, UK: Emerald.

Case, D. O., Johnson, J. D., Andrews, J. E., Allard, S. L., & Kelly, K. (2004). From two-step flow to the Internet: The changing array of sources for genetics information seeking. *Journal of the American Society for Information Science and Technology*, 55(8), 660–669.

Courtright, C. (2007). Context in information behavior research. In B. Cronin (Ed.), *Annual Review of Information Science and Technology*, vol. 41 (pp. 273-306). Medford, NJ: Information Today.

Dervin, B. (1997). Given a context by any other name: Methodological tools for taming the unruly beast. In P. Vakkari, R. Savolainen, & B. Dervin (Eds.), *Information seeking in context: Proceedings of an International Conference on Research in Information Needs, Seeking and Use in Different Contexts*, 14–16 August 1996, Tampere, Finland (pp. 13–38). London, UK: Taylor Graham.

Ellis, D. (1989). A behavioral model for information retrieval system. *Journal of Information Science*, 15(4-5), 237-247.

Ellis, D., Cox, D., & Hall, K. (1993). A comparison of the information seeking patterns of researchers in the physical and social sciences. *Journal of Documentation*, 49(4), 356-369.

Erdelez, S. (2005). Information encountering. In K.E. Fisher, S. Erdelez & L. McKechnie (Eds.), *Theories of information behaviour* (pp. 179-184). Medford, NJ: Information Today, Inc.

Foster, A. (2004). A nonlinear model of information-seeking behavior. *Journal of the American Society for Information Science and Technology*, 55(3), 228-237.

Furner, J. (2004). Conceptual analysis: a method for understanding information as evidence, and evidence as information. *Archival Science*, 4(3-4), 233-265.

Graham, D.W. (2015). Heraclitus. In *The Stanford encyclopedia of philosophy*. Retrieved from <https://plato.stanford.edu/archives/fall2015/entries/heraclitus>

Joho, H., Jatowt, A., & Blanco, T. (2015). Temporal information searching behaviour and strategies. *Information Processing & Management*, 51(6), 834-850.

Johnson, J. D. (2003). On contexts of information seeking. *Information Processing & Management*, 39(5), 735-760

Joseph, P., Debowski, S., & Goldschmidt, P. (2013). Search behavior in electronic document and records management systems: an exploratory investigation and model. *Information Research*, 18(1). Retrieved from <http://InformationR.net/ir/18-1/paper572.html>

Järvelin, K., & Pharo, N. (2004). The SST method: a tool for analysing Web information search processes. *Information Processing & Management*, 40(4), 633-654.

Kuhlthau, C.C. (1991). Inside the search process: information seeking from the user's perspective. *Journal of the American Society for Information Science*, 42(5), 361-371.

Kuhlthau, C.C. (1999). Investigating patterns in information seeking: concepts in context. In T.D. Wilson & D. Allen (Eds.), *Exploring the contexts of information behavior*. Proceedings of the 2nd

International Conference on Research in Information Needs, Seeking and Use in Different Contexts, 13-15 August 1998, Sheffield, UK (pp. 10-20). London, UK: Taylor Graham.

Kuhlthau, C.C. (2004). *Seeking meaning. A process approach to library and information services*. 2nd ed. Norwood, NJ: Ablex.

Leckie, G. J., Pettigrew, K. E., & Sylvain, C. (1996). Modelling the information seeking of professionals: A general model derived from research on engineers, health care professionals and lawyers. *Library Quarterly*, 66(2), 161–193.

Lin, S., & Belkin, N.J. (2005). Validation of a model of information seeking over multiple search sessions. *Journal of the American Society for Information Science and Technology*, 56(4), 393-415.

Marchionini, G. (1995). *Information seeking in electronic environments*. Cambridge: Cambridge University Press.

Meho, L.I. & Tibbo, H.R. (2003). Modelling the information-seeking behavior of social scientists: Ellis's study revisited. *Journal of the American Society for Information Science and Technology*, 54(6), 570-597.

Merriam-Webster Dictionary and Thesaurus (2017a). Cycle. Retrieved from <https://www.merriam-webster.com/dictionary/cycle>

Merriam-Webster Dictionary and Thesaurus (2017b). Phase. Retrieved from <https://www.merriam-webster.com/dictionary/phase>

Merriam-Webster Dictionary and Thesaurus (2017c). Process. Retrieved from <https://www.merriam-webster.com/dictionary/process>

Merriam-Webster Dictionary and Thesaurus (2017d). Stage. Retrieved from <https://www.merriam-webster.com/dictionary/stage>

Miles, M.B., & Huberman, A.M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). London, England: Sage.

Moral, C., De Antonio, A., & Ferre, X. (2017). A visual UML-based conceptual model of information-seeking by computer science researchers. *Information Processing & Management*, 53(4), 963-988.

Rescher, N. (2012). Process philosophy. In *Stanford encyclopedia of philosophy*. Retrieved from <https://plato.stanford.edu/entries/process-philosophy/>

Savolainen, R. (2006a). Spatial factors as contextual qualifiers of information seeking. *Information Research*, 11(4). Retrieved from <http://www.informationr.net/ir/11-4/paper261.html>

Savolainen, R. (2006b). Time as a context of information seeking. *Library and Information Science Research*, 28(1), 110-127.

Spink, A. (1997). Study of interactive feedback during mediated information retrieval. *Journal of the American Society for Information Science*, 48(5), 382-394.

Toms, E. (2002). Information interaction: providing a framework for information architecture. *Journal of the American Society for Information Science and Technology*, 53(10), 855-862.

Vakkari, P. (2001). A theory of the task-based information retrieval process: a summary and generalization of a longitudinal study. *Journal of Documentation*, 57(1), 44-60.

White, R.W. (2016). *Interactions with search systems*. Cambridge, UK: Cambridge University Press.

Wilson, M.L. (2017). The Tetris model of resolving information needs within the information seeking process. In *CHIIR '17*, March 7-11, 2017, Oslo, Norway (pp. 147-154). New York: ACM.

Wilson, T.D. (1997). Information behaviour: an interdisciplinary perspective. *Information Processing & Management*, 33(4), 551-572.

Wilson, T.D. (1999). Models in information behavior research. *Journal of Documentation*, 55(3), 249-270.

Wilson, T.D. (2000). Human information behaviour. *Informing Science*, 3(2), 49-56. Retrieved from <http://www.inform.nu/Articles/Vol3/v3n2p49-56.pdf>

Wilson, T.D. (2010). Information behavior models. In M.J. Bates & M.N. Maack (Eds.), *Encyclopedia of library and information sciences*. 3rd. ed. (pp. 2392-2400). London, UK: Taylor & Francis.

Xie, I. (2009). Dimensions of tasks: influences on information-seeking and retrieving process. *Journal of Documentation*, 65(3), 339-366.