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Pioneering models for information interaction in the context of information seeking and retrieval

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Abstract

Purpose – The purpose of this paper is to clarify the conceptual issues of information behaviour research by reviewing the approaches to information interaction in the context of information seeking and retrieval (IS&R).

Design/methodology/approach – The study uses the conceptual analysis focussing on four pioneering models for interactive IS&R proposed by Belkin, Ingwersen and Ingwersen and Järvelin.

Findings – A main characteristic of models for information interaction is the tripartite setting identifying information resources accessible through information systems, intermediary/interface and user. Dialogue is a fundamental constituent of information interaction. Early models proposed by Belkin and Ingwersen focussed on the dialogue occurring in user-intermediary interaction, while more recent frameworks developed by Ingwersen and Järvelin devote more attention to dialogue constitutive of user-information system interaction.

Research limitations/implications – As the study focusses on four models developed within the period of 1984-2005, the findings cannot be generalised to depict the phenomena of information interaction as a whole. Further research is needed to model the specific features of information interaction occurring in the networked information environments in particular.

Originality/value – The study pioneers by providing an in-depth analysis of the ways in which pioneering researchers have conceptualised the phenomena of interaction in the context of IS&R. The findings contribute to the elaboration of the conceptual space of information behaviour research.

Keywords Information retrieval, Interaction, Modelling, Models, Information seeking, Information interaction, Interactive information retrieval, Interactive information seeking

Paper type Conceptual paper

Introduction

Since the 1990s, interaction has become a cross-cutting construct embedded in information-seeking and retrieval research (Jansen and Rieh, 2010, p. 1527). In this context, the issues of interaction have been approached by diverse terms such as information retrieval (IR) interaction (Ingwersen, 1992), interaction in IR (Saracevic, 1996), interaction in information searching and retrieval (Beaulieu, 2000), interactive information seeking (Xu, 2007), interactive IR (Ruthven, 2008), information interaction (Toms, 2002) and human-information interaction (HII) (Marchionini, 2008). In addition, there are related expressions such as human-computer interaction (HCI) (Lin, 2010), interacting with information (Blandford and Attfield, 2010) and interacting with information systems (White, 2016).

The above examples suggest the existence of a rich, though overlapping and somewhat chaotic terminology characterising the interactive qualifiers of IR in particular. Unfortunately, so far, researchers have seldom reflected the nature of these qualifiers in greater detail. This may be due to that concepts such as interaction and interactive are found self-explanatory and thus intelligible without further definition. This approach can

indicate the basic difficulty faced in trying to capture the meaning of generic constructs such as interaction.

The main goal of the present study is to clarify the conceptual issues of information behaviour research by examining how researchers have characterised the construct of interaction as a component of information seeking and IR. To this end, an in-depth conceptual analysis was made by concentrating on four key models characterising the elements of information interaction and its nature as a mode of human action. These models were developed by the pioneers of the study of interactive information seeking and retrieval (IS&R): Nicholas Belkin and his associates, Peter Ingwersen and Kalervo Järvelin. Even though the earliest model dates back to the pre-internet era, the frameworks reviewed in the present study are continually relevant because they crystallise the perennial issues of IS&R, that is, the relationships between information seekers, human intermediaries, information resources and information systems. The above models are also relevant for information behaviour research because they demonstrate how researchers have conceptualised the basic issues of interactive IS&R since the 1980s until the mid-2000s, thus gradually building the theoretical foundation for the study of these phenomena. Even though empirical research on interactive information searching and retrieval has remarkably expanded during the past ten years, the pioneering models are still relevant. This is because in the recent years, the modelling of information interaction has progressed slowly, thus implying the difficulty of developing radically new ideas to conceptualise these phenomena. For example, the examination of the proceedings of major conferences such as Information, Interactions and Impact (i³), Information Interaction in Context (IIiX) and the ACM SIGIR Conference on Human Information Interaction and Retrieval (CHIIR) revealed no major attempts to develop theoretical or generic models for information interaction. For instance, the Tetris model (Wilson, 2017) discussed in CHIIR 2017 focusses on resolving information needs within the information-seeking process; however, no new ideas about the nature of information interaction are introduced.

The rest of the paper is structured as follows. The next section provides background for the conceptual analysis by characterising the key concepts of interaction, interactive IS&R and information interaction. Thereafter, the research framework will be specified, followed by the explication of the research questions and methodology. The research findings will be reported by concentrating on the analysis of the four models referred to above. The final section discusses the research findings and draws conclusions of their significance.

Background and terminological issues
Interaction
Generally defined, interaction can be understood as a "reciprocal event that requires at least two objects and two actions. Interaction occurs when these two objects and events mutually influence each other" (Wagner, 1994, p. 8). Thus, the idea of a two-way effect is essential in the concept of interaction, as opposed to a one-way causal effect.

The term interaction has different meanings in diverse fields of inquiry. Sociologists and social psychologists approach the field of study in terms of social interaction. It can generally be understood as a dynamic sequence of actions (exchange) between individuals or groups who modify their actions and reactions due to actions by their partner(s) (e.g. Argyle, 2009). Communication researchers primarily approach the issues of interaction in terms of communication, sometimes, the above concepts are used interchangeably (Chandler and Munday, 2016). However, interaction and communication are not synonymous constructs because it is possible to have one-way communication without interaction (e.g. watching TV) but not interaction without communication. The issue becomes more complicated if we consider how an individual reading a printed book "interacts" with the text. It is obvious that this is not interaction in the sociological sense

because there is no genuine reciprocity and exchange between the two components involved (Jensen, 1998, p. 188). Because the printed text in itself can neither adapt nor react to the reader's actions, the concept of interaction is primarily used in the sense of "interpretation" or "reception". Moreover, in studies on interpersonal communication, interaction is characterised in terms of dialogue by focussing on the routinised, contextualised and usually dyadic exchanges between individuals (Neuman, 2008). In this context, interaction comes into being when each of at least two participants is aware of the presence of the other, the partners in the interaction are in close physical proximity, and symbolic interaction is also involved (Jensen, 1998, p. 188). In library and information science studies, a traditional example of interaction situation of this kind is the reference interview between the librarian and a library user (Taylor, 1968).

Since the 1970s, HCI sometimes also termed computer-human interaction has examined the ways in which humans make, or do not make, use of computational artifacts, systems and infrastructures (Grudin, 2011). HCI is a multidisciplinary research area situated at the intersection of computer science, behavioural sciences, design research and information science; much of the research in this field seeks to improve HCI by improving the usability of computer interfaces. HCI can occur at diverse levels (Beaulieu, 2000, p. 433). Starting at the lowest level, interaction occurs through different physical devices (e.g. keyboard, mouse and screen) which allow the information system and the user to communicate in different ways and establish a dialogue for executing tasks. At the syntactic level, a set of actions or operations is combined in order to carry out a task (e.g. by means of mouse clicks for printing a piece of text). The semantic level of HCI is concerned with how tasks are defined or represented (e.g. task options presented as commands). At the highest level, there are operational tasks themselves which make up a particular application (e.g. different text-editing tasks such as cut and paste). Thus, HCI occurs through a user/system dialogue which takes the form of inputs and outputs (Beaulieu, 2000, p. 433). The user initiates an action or operation and the system responds in some way which in turn leads the user to initiate another action.

Interactive IS&R

The notion that IS&R involve an interactive exchange between a user and an information environment is not new because the first studies on this topic can be traced to the 1960s (Savage-Knepshield and Belkin, 1999, pp. 1067-1068). Taylor (1968) was among the first scholars recognising the interactive nature of information seeking and the importance of question negotiation between library users and reference librarians. Because the users tended to express their needs to librarians as open-ended descriptions of an area in doubt, an interactive question-negotiation process (i.e. dialogue) is required to successfully resolve the information need. Even though Taylor (1968) did not use expressions such as interactive information seeking or interactive IR, his findings are relevant for the present investigation because they explicitly deal with the user's ability to meet his or her information need by using a human-to-human communication process.

More systematic efforts to examine the nature of user-intermediary interaction began in the 1980s (Belkin and Vickery, 1985; Cool and Belkin, 2011, p. 12). Pioneering contributions to the study of IR interaction include the study of the Bookhouse retrieval system by Pejtersen (1980). To identify the interaction strategies employed by users looking for fiction, she examined dialogues between librarians and users. Similarly, Belkin (1980, 1984) and Ingwersen (1982) were among the first researchers refining the empirical picture of intermediary-assisted information searching taking place in libraries. The interest in the issues of interactive IR began to grow in the 1990s. One of the major contributions is Ingwersen's (1992) doctoral dissertation on IR interaction. Ingwersen (1992) characterised IR interaction broadly as "the interactive communication processes that occur during retrieval

of information by involving all major participants in IR, i.e., the user, the intermediary, and the IR system – the latter consisting of potential information, mainly in the form of text and text representations as well as IR system setting" (p. 228).

Somewhat later, Saracevic (1996) proposed a stratified model of IR interaction. The model characterises information interaction at three main strata or levels. At the surface level, a user interacts with an information system through an interface by issuing commands or queries that represent a problem statement. At the same level, the system responds either with meta-information, or texts, including images, or with queries of its own designed to elicit from the user further information on the nature of the problem. At the cognitive level, the user interacts with the output of the system, or with texts obtained subsequent to system interaction, in ways that enable the user to assess the utility of the text in relation to the initial problem. Finally, at the situational level, users interact with the given situation or problem at hand which produced the information need and resulting question. The results of the search may be applied to the resolution or partial resolution of the problem. Importantly, the stratified model suggests that IR interaction consists of a series of dynamic interplays and adaptations between levels (Saracevic, 1996, p. 7). As the interaction progresses, things change. For instance, on the surface level, a query may be changed, terms added or deleted, different tactics employed, reflecting and affecting changes at other levels. In addition, interaction can also be treated as an interplay between different user and computers strata or levels realised on the surface level through the interface. More recently, Byström and Hansen (2005, p. 1057) characterised IR interaction in greater detail by identifying key aspects of interaction with any type of source. The interactive aspects include, for example, query reformulation and relevance feedback which allows the searcher to locate more documents similar to those marked previously.

Given the variety of approaches to interactive information seeking and IR, Cool and Belkin (2011, p. 1) concluded that the construct of IR interaction defies an exact definition because there are at least three ways in which interaction in an IR system occurs: between the information seeker and an intermediary; between the intermediary and the collection; and between the information seeker and the collection. The lack of a precise definition of concepts such as IR interaction makes it difficult to determine the extent to which individual models for IS&R would be relevant for the conceptualisation of information interaction. For example, Bates's (1979, 1990) framework for information search tactics specifies how search behaviour is constituted by four major factors, that is, move, tactic, stratagem and information search strategy. However, the above studies do not conceptualise the nature of information interaction; the main emphasis is placed on the ways in which the searcher may plan to execute a search. More recently, Xie (2007) presented a planned-situational model specifying shifts in information-seeking strategies (ISSs) in IR in the digital age. From the perspective of the present study, her model incorporates a potentially relevant component, that is, interactive intentions. However, this component refers to sub-goals that a user has to achieve in the process of accomplishing his or her current search task. Similar to Bates, Xie makes no attempts to conceptualise the phenomena of information interaction. Therefore, due to the emphasis on information search tactics or strategies rather than information interaction, the above frameworks exemplify studies which were excluded from the present study.

Information interaction
Similar to the constructs of interactive IR and interaction in IR, early references to the phenomena of information interaction can be traced to the 1980s. This term appears, for example, in Belkin's (1984, p. 117) study proposing a model of the cognitive communicative system. The terminological repertoire was enriched further in 1995 when Nahum Gershon coined the term HII in an effort to focus HCI efforts on understanding "how humans interact with information regardless [of] the medium they use" (Jones *et al.*, 2006, p. 67).

The terms information interaction and HII were taken quite slowly into a broader use because researchers preferred concepts such as interaction in IR (Saracevic, 1996) and interaction in information searching and retrieval (Beaulieu, 2000). The term information interaction gained new proponents, however. For example, Toms (2002, p. 856) characterised information interaction as a complex process that integrates aspects of the user, the content and the system that delivers the content to the user. Later on, Marchionini (2008, p. 170) preferred the concept of HII in order to emphasise the importance of the relationship between human actor and information (objects) in the study of interaction processes. Marchionini (2008, p. 170) identified seven components that are particularly relevant for research on HII:

(1) entities, that is, humans and information;

(2) the genesis of the actions (initiation) – by humans or information objects;

(3) the nature of the actions – mental and physical;

(4) the ways people interact with information with the technology as an intermediary;

(5) the amplitude (intensity) of interaction – small (incremental) or large;

(6) frequency of the reciprocity cycles – slow or rapid, regular or chaotic; and

(7) the resultant changes in the participating entities: the differences in mental states of the human and physical or digital states of information objects.

More recently, Fidel (2012) dedicated a whole book on the phenomena of HII. Fidel (2012, p. 274) characterised the nature of HII somewhat tautologically by referring to a multidisciplinary area of research that investigates "how humans interact with information". According to Fidel (2012, p. 274), HII is manifested as human information behaviour in library and information science and as HCI in computer science. Once again, general-level characterisations such as these indicate that the phenomena of HII are difficult to capture in an exact definition. This is partly due to that along with the breakthrough of the internet, "interactive" has become a pervasive qualifier of information systems; therefore, almost all information searching and retrieval is nowadays interactive in nature (Ruthven, 2008, p. 45).

Research framework and research questions

The above review revealed the multiplicity of views on the phenomena of interaction in the context of information seeking and IR. The term interaction and its derivative "interactive" appear as components of diverse constructs such as IR interaction and HII. To clarify the focus of the present study, information interaction was chosen as an umbrella category. It was preferred due to its generic nature because information interaction is assumed to be a cross-cutting qualifier of specific activities such as interaction in IR and interactive information searching. The study draws on Marchionini's (2008, p. 170) idea suggesting that humans and information resources (or information objects), and interaction (as a mode of action) are key components in research on information interaction. As the above review suggests, the key components of information interaction also include human intermediaries and information systems. To strengthen the focus of the study, the present investigation examines the nature of information interaction by concentrating on the relationships between information seekers (users), human intermediaries and information systems. The research framework is depicted in Figure 1.

In Figure 1, the type of information interaction of primary interest for the present study is indicated by two-pronged arrows, while the dashed arrows indicate a secondary research interest. Following Wagner (1994, p. 8), interaction is generally understood as a "reciprocal

event that requires at least two objects and two actions. Interaction occurs when these two objects and events mutually influence each other". The framework identifies two key interactions to be examined in the present study. First, there is the interaction between the information seeker (user) and human intermediary, for example, a librarian helping in the identification of information resources. Second, there is the interaction between the user and the information systems such as search engines enabling access to information objects.

To examine the above interactions, the study concentrates on four key models specifying the nature of information interaction: the cognitive model of the communication system proposed by Belkin (1984), the framework for ISSs developed by Belkin *et al.* (1993), the cognitive model of interactive IR presented by Ingwersen (1996) and the integrative model for IS&R proposed by Ingwersen and Järvelin (2005). At the early stage of the study, Saracevic's (1996) stratified model of IR interaction was included in the comparative research setting. Finally, however, his framework was excluded because the stratified model approaches information interaction on a general level; the framework primarily identifies relevant issues for future research on IR interaction. The focus on the pioneering models proposed by Belkin, Ingwersen and Järvelin can be justified by four main reasons. First, although the earliest frameworks are quite old, the four models provide, so far, the most sophisticated conceptualisations of the phenomena of information interaction. Second, these four models effectively identify the main components of information interaction and specify their relationships. Third, the above models are useful in that the issue of information interaction can be examined in a focussed way, without the need of scrutinising the details of empirical studies describing, for example, the features of user-intermediary interaction in specific contexts such as school libraries. Finally, the analysis of these models reveals how the conceptualisation of information interaction has progressed since the early 1980s.

Drawing on the above framework, the present study addresses the following research questions:

RQ1. In which ways have researchers characterised information interaction between information seekers (users) and human intermediaries in the pioneering models of interactive IS&R?

RQ2. In the above models, in which ways have researchers characterised information interaction between information seekers (users) and information systems?

RQ3. What kind of similarities and differences can be identified from the above characterisations?

Research material and method
For the systematic identification of pertinent research material, EBSCO Host Academic Search Premier, Google Scholar, Library and Information Science Abstracts and Scopus were searched. In addition, the papers presented in three major conferences focussing on the issues of information interaction were examined. These conferences include i³ (2007-2017), IIiX (2006-2014) and the ACM SIGIR CHIIR (2016-2017). The following keywords were used in the literature searches: interaction, information interaction, HII, interactive information seeking, interactive information searching and interactive IR. No time frame was used in the
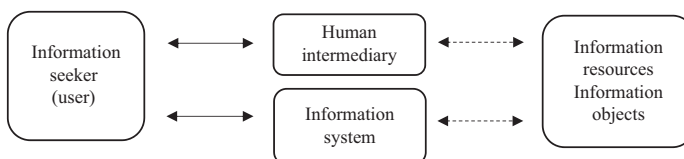

Figure 1.
The research
framework

searches because an attempt was made to identify pertinent research material as extensively as possible. This effort resulted in the identification of 98 potentially relevant articles, books and conference papers published within the period of 1968-2017. The sample included books, research articles, conference papers and review articles.

The preliminary analysis of these studies revealed that the most of them draw on the pioneering models for interactive IR developed by Belkin (1984), Ingwersen (1996), Saracevic (1996) and Ingwersen and Järvelin (2005), thus suggesting that these frameworks are potentially most fruitful for the analysis of information interaction. Somewhat surprisingly, the papers presented in the above conferences (i[3], IIiX and CHIIR) were not particularly relevant for the needs of the present study because most studies focus on empirical issues of interactive information seeking and IR, with no particular contribution to the conceptualisation or modelling of the phenomena of information interaction. A similar conclusion can be made regarding the empirical investigations of interactive query reformulation (e.g. Xie and Joo, 2010) and relevance judgements (e.g. Chu, 2011). These findings confirmed the decision to concentrate on the four key models to be examined in greater depth below. Thus, the core of the research material was formed by four studies, that is, Belkin (1984), Belkin *et al.* (1993), Ingwersen (1996) and Ingwersen and Järvelin (2005). In addition, the research material included investigations reviewing or commenting the above models (e.g. Lin, 2010; Saracevic, 1996; Wilson, 1999), as well as studies drawing on the ideas presented in the pioneering frameworks (e.g. Yuan and Belkin, 2014).

The research material was examined by means of evolutionary concept analysis (Rodgers, 2000). This method emphasises the dynamic nature of concept development by examining the application of concepts within a given context or group of contexts in order to identify its attributes within that context (Fleming-May, 2014, p. 205). The analysis includes six major steps:

(1) identify the concept of interest and associated expressions;

(2) identify and select an appropriate setting and sample for data collection;

(3) collect data relevant to identify the attributes of the concept, and the contextual basis of the concept;

(4) analyse data regarding the above characteristics of the concept;

(5) identify an exemplar of the concept; and

(6) identify implications for further development of the concept.

In the present study, the concepts of main interest are information interaction, interactive information seeking and interactive IR (step 1). The data collection was described above (step 2). As to step 3, the terminology proposed by Rodgers (2000) was slightly modified in that the present study prefers the term constituent, not attribute while examining the characteristics of information interaction. At the next phase (step 4), the constituents of such activities were analysed. To this end, the research material was examined to identify factors that are conceptually related to the phenomena of information interaction. More specifically, attention was devoted to how researchers have approached the constituents of such constructs as indications of information interaction. No coding instrument was developed for this purpose because the relevant constituents could be identified by scrutinising the components of the four models expressing the relationships of concepts in graphic form by means of diagrams. Relevant constituents thus identified include, for example, intermediary's model of the user (Belkin, 1984) and cognitive actor (Ingwersen and Järvelin, 2005). After having identified such constituents, the analysis was continued by comparing the characterisations of the constituents presented by various researchers. Then, exemplars depicting information interaction were identified from the four models (step 5).

Finally, implications for the further analysis of the concept of such constructs were identified (step 6).

The conceptual analysis was rendered difficult due to the fact that researchers often employ the terms information interaction and interactive IR in an unspecified manner. Moreover, developing an effective way of reporting the research findings appeared to be a demanding task. There were two main alternatives: either to take the type of interaction, that is, user-human intermediary interaction (RQ1) and user-information system interaction (RQ2) as a point of departure, or to focus on the ways in which diverse models characterise the above types of interaction. Finally, the latter approach was chosen because the former would have resulted in an unnecessary repetition while characterising the components of the individual models. The latter approach also appeared to be preferable because the issues of user-human intermediary interaction and user-information system interaction can be examined together. The findings will be reported author-wise by starting from the early models developed by Belkin (1984) and Belkin et al. (1993), followed by the frameworks proposed by Ingwersen (1996) and Ingwersen and Järvelin (2005). Characteristic of the evolutionary concept analysis (Rodgers, 2000), the models are examined in a chronological order because this allows the study of how the conceptualisations of information interaction have been elaborated since the 1980s.

Findings

Belkin's cognitive model for communicative interaction

Since the late 1970s, Belkin embraced the ideas of the cognitive viewpoint and made attempts to model a communication system for IR informed by this research perspective. From the first beginning, the modelling was based on the identification of three key components: authors, users and IR system (Belkin, 1980, pp. 135-136). It was assumed that authors generate some aspect of his or her knowledge to the audience by means of texts. In an IR situation, these texts are conceived of as physical records which become a part of the IR text store. From the other end of the communication system, a user realises that there is an anomaly in his or her state of knowledge with respect to the problem faced. This realisation leads to a recognised anomalous state of knowledge (ASK), which, further modified by linguistic and pragmatic consideration becomes a request put to an IR system. However, there is often a mismatch between the user's need and the request because the texts may be inappropriately represented in the IR system, the need cannot be expressed appropriately in the system's terms, or the need in itself is unspecifiable at the cognitive level. Over a decade earlier, Taylor (1968) had approached these issues from the perspective of dialogue occurring between the user and intermediary in the context of question-negotiation process. Similarly, Belkin (1980, p. 139) maintained that a central issue in the development of the communicative system for IR is how the user's ASK can be appropriately represented to the IR system. Belkin (1980, p. 140) believed that the mismatches between user's need and request can be best solved by means of "iterative interaction". It is a process in which the user communicates with the IR system by representing an initial request and then gradually refines his or her ASK by interpreting the texts retrieved by means of the IR.

Belkin (1982) elaborated the above issues by reviewing the models of dialogue for IR. This study also clarified Belkin's (1982) approach to the construct of interaction which was characterised as "descriptions by the user of the user's (changing) ASK, so that the mechanism's model of ASK, and perhaps of texts, can be modified appropriately" (p. 18). The above characterisation was further refined by approaching interaction in the context of IR as a phenomenon that has some of the characteristics of normal conversation, and of certain types of restricted dialogue such as interviews between human actors (Belkin, 1982, p. 20). This approach suggests that human-IR system interaction would be most effective if

it is treated as conversation, similar to dialogue between human to human. In a seminal study on ASK for IR, Belkin *et al.* (1982, p. 65) drew on Belkin's (1980) prior investigation by suggesting that interactions of human with another, with the physical world and with themselves are always mediated by their states of knowledge about themselves and with what or whom they interact. The above investigations provided a useful basis for the refinement of the communication system for IR depicted in Figure 2. This framework considers the dynamic interaction among three components: the user; the knowledge resource (KR); and the intermediary mechanism between the first two components (Belkin, 1984).

The model is based on the idea of cognitive models or images that the actors of the communication system have of one another and of themselves. The framework also incorporates functionalistic ideas because it is assumed that authors, users and intermediaries occupy specific roles when they serve the ends of the whole communication system. Characteristic of the era of online database searching, Belkin's model focusses on the interaction between the user and the human intermediary, while the features of interaction occurring between the user and information system are not specified in greater detail. The model suggests that the intermediary, to whom the user communicates the request, devises an appropriate strategy for retrieving information from the KR, that is, texts potentially useful for the user in managing the user's problem. The intermediary mechanism mediates between the user's desires, requirements and knowledge, and the KR's contents, representation and organisation, so that if texts appropriate to the user's situation are in the KR, they (or aspects of them) are brought to the user's attention.

The picture of the user-human intermediary interaction was elaborated further by drawing on the findings of an empirical study. Its data were gathered by tape-recorded interviews concentrating on the dialogues between library users and intermediaries in real IR situations (Belkin, 1984, p. 117). The focus was placed on a co-operative dialogue, in which the ostensible goal of the intermediary was to provide information to the user, based on the KR. The findings indicated that in the beginning of the interaction, the intermediary was primarily concerned with building up a model of the user's problem. Towards the end of interaction, the intermediary went back to building up a better model of the user. It also appeared that the intermediary led the interaction, and that the users accommodated themselves to patterns established by the intermediary in order to keep the conversation going. The intermediary and
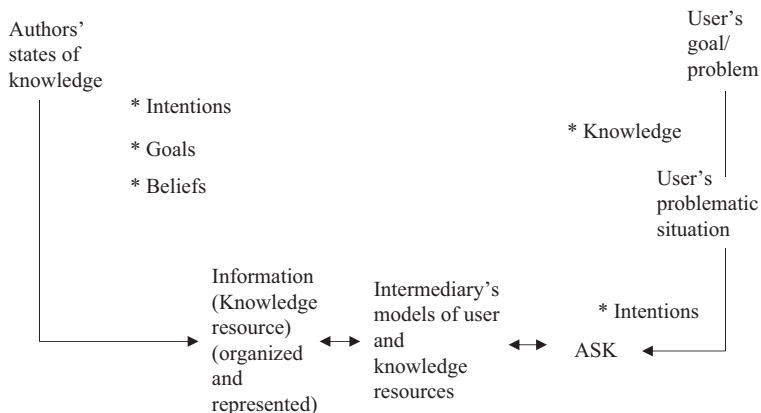

Figure 2.
The cognitive communication system for IR

Note: *Transformations of knowledge structures
Source: Belkin (1984, p. 114)

user co-operated in building up the model of the user's goals and background, before establishing a final retrieval strategy.
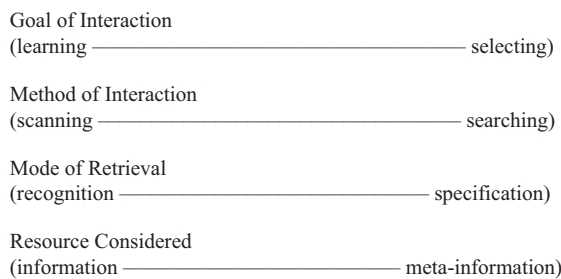
Overall, the cognitive communication model depicted in Figure 2 approaches information interaction in terms of dialogue departing from the characterisation of the user's ASK and ending with the evaluation of the relevance of information retrieved from an information system. In this respect, Belkin's approach to information interaction comes close to the setting of question-negotiation process examined by Taylor (1968). Thus, compared to the prior studies on ASK (Belkin, 1980; Belkin *et al.*, 1982), there was a shift of interest from the representation of user's ASK directly to an IR system to the issues of dialogue constitutive of intermediary-assisted searching. This shift is probably due to the difficulty of modelling the wide variety of user's' situation-specific ASKs – a perennial problem of IR system design.

The model for ISSs

Another major contribution to the study of information interaction is the model for ISSs developed by Belkin *et al.* (1993). Different from the cognitive communication system model emphasising the importance of user-intermediary dialogue, the ISSs framework focusses on how the users interact with information systems. Moreover, different from the above model, Belkin *et al.* (1993) preferred the term information seeking, although it is often used interchangeably with the concept of IR. In general, ISSs refer to a variety of behaviours people engage in while searching for information in some KR (Belkin *et al.*, 1993). Importantly, such ISSs are conceived of as interactions between the user and the other components of the IR system. Similar to the model for the cognitive communication system, the ISSs framework departs from the assumption that information seeking is primarily built on the user's interaction with texts and that such interaction necessarily implies interpretation. Different from Belkin's (1984) earlier model, the ISSs framework does not reserve any particular role for intermediaries.

The rationale of the ISSs model is to specify the entities with which the person interacts and characterise the interaction processes in which the person engages during the information-seeking process. To this end, the model specifies a multidimensional space of ISSs by positing four key dimensions constitutive of such strategies. The dimensions are: the goal of interaction, the method of interaction, the mode of retrieval and the type of information resource interacted with. The model is depicted in Figure 3.

The model suggests that any ISS can be characterised according to its values on four dimensions. The explicit combination of poles of each dimension leads to a set of $4 \times 4 = 16$ prototypical ISSs. As the ISSs model is primarily an abstract classification scheme, it does not detail every characteristic of information interaction. From the perspective of the present study, the dimension of the method of interaction is most pertinent. The above

Goal of Interaction
(learning ——————————————— selecting)

Method of Interaction
(scanning ——————————————— searching)

Mode of Retrieval
(recognition ——————————————— specification)

Resource Considered
(information ——————————————— meta-information)

Source: Belkin *et al.* (1993, p. 325)

Figure 3.
The model for
information-seeking
strategies

dimension can have two values, scanning or searching. This dimension can be understood in terms of the classic distinction between searching for a known item and scanning for something interesting among a collection of items (Belkin *et al.*, 1993). Thus, interaction with information items themselves can be contrasted with interaction with meta-information resources that describe the structure and contents of information objects.

Belkin (1996) illustrated a prototypical ISS by describing the ways in which user-information system interaction can take place in database searching. The person first puts a specific query to a database, in order to learn whether there are documents in it which might be relevant to his or her problem. Having perused some documents found in this way, and having judged them all to be non-relevant, the person begins to explore, perhaps through a thesaurus, other ways that the concepts in which she is interested. Finding one such concept that seems likely, she looks at a document which is indexed by that concept. Liking what she sees, she looks through some other documents that seem closely related to that one. On the basis of some relevance judgments on these documents, a query is generated to search again in the database. The documents which are retrieved by this comparison process are presented to the person as a set of classes of related documents. The user, judging one of the classes to be quite interesting, asks for a summary of those documents. A summary is presented to the user, which gives her enough information so that she can do the task which leads to her goal of learning about a new topic, and the episode is terminated.

Although the above example is helpful in the characterisation of prototypical ISSs, the picture of information interaction as a mode of human action remains abstract. This is due to the classificatory approach. By placing the emphasis on the interaction between information seeker and information system, Belkin *et al.* (1993) anticipated the shift from intermediary-assisted IR to information seeking conducted by the end users. However, the issues of dialogue central to the cognitive communication model (Belkin, 1984) were not set aside; they were now approached from the perspective of user-information system dialogue. To this end, Belkin *et al.* (1995) proposed a framework of IR system design that provides a means for supporting users in their various information-seeking behaviours. The framework departed from the assumption IR is most properly considered as interaction, and that in the context of ISSs, it can be modelled as a dialogue. To this end, particular dialogue structures (scripts) can be associated with different ISSs. Said otherwise, each region of the ISS space may be associated with a prototypical dialogue structure, which takes place between the user and the IR system. Belkin *et al.* (1995) also proposed that the techniques of case-based reasoning can be used to structure patterns of interactions involving combinations of ISSs and that the interplay of ISSs, dialogue structures, scripts and cases can be used in a system design strategy. To test the above ideas, Belkin *et al.* (1995) developed MERIT – a prototype IR system incorporating the above design principles. However, as these issues mainly deal with the potential of computerised systems to support IR, they will not be discussed in greater depth.

More recently, Yuan and Belkin (2014) revisited the above ideas by developing an information-seeking dialogue model in an interactive IR system. More specifically, interaction with the system was approached as a dialogue between the user and the computer through the interface for the purpose of effectively using information by affecting the cognitive state of the user. Essentially, a user carries out a dialogue through an interface by making utterances (e.g. commands) and receiving responses (e.g. computer utterances). The empirical study showed that the interaction follows pre-specified, but highly flexible dialogue structures for specific ISSs (Yuan and Belkin, 2014, p. 842). The findings also illustrate how the different sequences are responsive to the pre-existing knowledge state and goals of the user, and how these conditions lead to specific case sequences, branchings and sub-cases during the interactive IR processes.

Ingwersen's cognitive model for interactive IR
Ingwersen has contributed to the studies on information interaction since the early 1980s. Drawing on observation and think aloud data, Ingwersen (1982) examined the cognitive aspects of users' interactions with the information system and self-representations of their problem statements during consultations with librarians. The study was continued by the empirical analysis of communication occurring between library users and intermediaries (Ingwersen, 1986). The above issues were elaborated from the cognitive viewpoint in Ingwersen's (1992) doctoral thesis on IR interaction. Similar to Belkin (1984), Ingwersen identified information resources available in IR systems and users potentially seeking access to such resources. In Ingwersen's (1992) study, an individual user occupies a central role in IR interaction, even though it is assumed that IR mainly takes place with the assistance of a human intermediary. Similar to Belkin's (1984) model, it is assumed that the intermediary's models of the user needs and IR affects the ways in which the user is assisted during the IR process. On the other hand, the construct of interaction was not characterised in greater detail.

The above approach was elaborated further in Ingwersen's (1996) seminal article where he specified the elements of a cognitive IR theory. The refined cognitive model of IR interaction is depicted in Figure 4.

As Figure 4 illustrates, the ideas of the cognitive viewpoint are emphasised by introducing a host of mental "models" depicting the nature of information objects, IR system setting and an individual user's cognitive space. Ingwersen (1996) proposed that within each area of the framework depicted in Figure 4, the functions of the information user, the document author, the intermediary, the interface and the IR system are the result of explicit
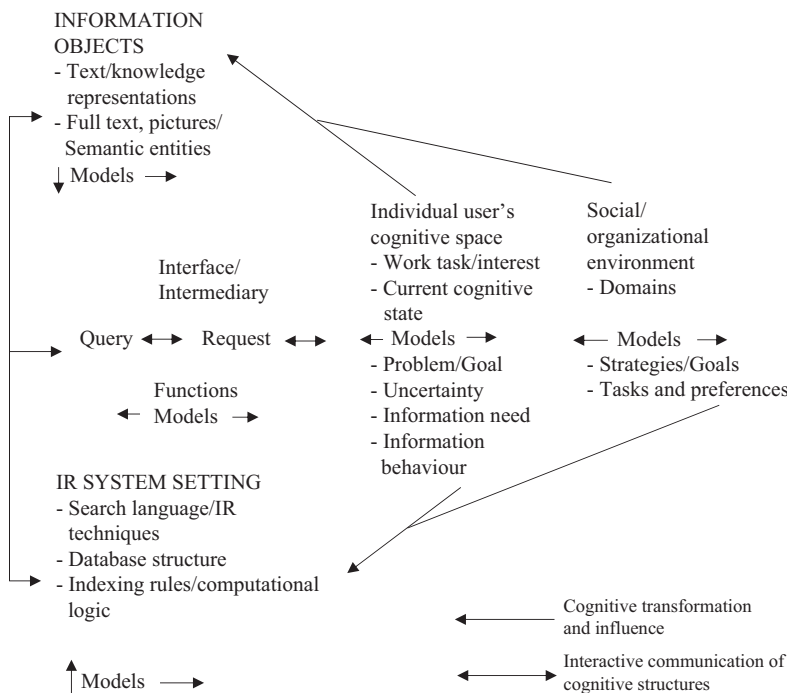
Source: Ingwersen (1996, p. 9)

Figure 4.
Cognitive model of
IR interaction

or implicit cognitive models of the domain of interest at that particular point. Thus, users have models of their work tasks or their information needs, or their problems or goals, which are usually implicit, but often capable of explication (Wilson, 1999, pp. 258-260). Different from Ingwersen's (1992) previous study, the component of intermediary is replaced by the construct of interface/intermediary; this suggests that information interaction may also occur between the end user and an IR system.

In Figure 4, the two-pronged arrows indicate "interactive communication of cognitive structures" – a key concept of the cognitive model. This is because Ingwersen (1996) conceives of interaction as acts of cognition based on the interplay of the actors' diverse cognitive or mental models. Figure 4 suggests that users interact not only with the sub-components of IR system such as search language and indexing rules but also with information objects, i.e., texts, pictures and semantic entities. Thus, interactive communication of cognitive structures may occur in various instances. First, there is "vertical" interaction between information objects and IR system setting. Interaction of this type is mediated by an individual user's current cognitive state, as well as the nature of his or her work tasks, interests, problem at hand, goal of action, state of uncertainty and information need. Second, "horizontal" interaction takes place between query and request interpreted by the intermediary and affected by the functionalities of computer interface. Moreover, there is interaction between request and the cognitive model of the individual, as well as his or her cognitive model of social and organisational environment plus his or her strategies or goals, tasks and preferences.

However, Ingwersen does not explain what is meant by "interactive communication of cognitive structures" or what happens when a user's cognitive space "interacts" with a text. A question arises whether "interacting with texts" would be better approached in terms of information use, text interpretation or text reception because it is evident that texts and documents *per se* cannot "act back" to the user and thus there exists no genuine reciprocity (Jensen, 1998, p. 188). In addition, the model suggests that various cognitive transformations take place when the user experiences a problem or identifies a goal to a situation in which a store of pointers to information objects can be satisfactorily searched and useful objects identified. On the other hand, the relationships between interactive communication of cognitive structures and cognitive transformations are not characterised in greater detail.

Overall, the picture of the information interactions – characterised in terms of communication of cognitive structures – is fairly complicated because there is a number of cognitive models involved in the above setting. On the other hand, the picture of user-intermediary interaction is somewhat more concrete. According to Ingwersen (1996, p. 17), the vital activity during interaction occurs when passages of information sources and indexes are presented to the user (and the intermediary). These tripartite interactions force the user either to reformulate an already conscious need and the problem state, or to formulate his underlying reasons for obtaining information in the case of an intrinsically vague need. In addition, the feedback from the system encourages the intermediary to ask certain types of questions, particularly when the sources do not provide the requested information.

According to Saracevic (1996, p. 5), the strength of Ingwersen's model lies in the detailed description of the interactions between the searchers and the systems, while the weaknesses of the model could be its testability and application to the evaluation of interactive IR system. As Lin (2010, p. 2185) reminds, however, the main purpose of Ingwersen's model was to inform the design of an interactive IR system with a descriptive account of the essential processes from both the user and system perspectives. Therefore, the model should not be interpreted as a detailed description of the content of information interaction occurring in specific context of IS&R.

Ingwersen and Järvelin's integrative model for interactive IS&R
So far, the most systematic model for information interaction is provided by the integrative
IS&R framework developed by Ingwersen and Järvelin (2005). It elaborates Ingwersen's (1996)
prior model by specifying a host of factors constitutive of interactive IS&R (see Figure 5).

Similar to Ingwersen's (1996) model, the framework depicted in Figure 5 draws on the
cognitive viewpoint. The model consists of five main components: information objects,
information technology (IT), interface, information seeker and the context of IS&R.
The relationships between the components are indicated by arrows of two types.
One-pronged arrows symbolise cognitive transformation and influence over time, while
two-pronged arrows indicate interaction of cognitive structures. Interestingly, the latter
arrow has been labelled more generally by replacing the construct of "interactive
communication of cognitive structures" (Ingwersen, 1996) with "interaction of cognitive
structures". This suggests that the model no longer emphasises the communicative aspect
of interaction. On the other hand, the communicative aspect is retained in the definition of
the concept of interaction, which is generally referred to as "the exchange between two or
more contexts of actors and a two-way communication activity" (Ingwersen and Järvelin,
2005, p. 300). Most importantly, however, the model specifies four main interactions occurring
between information seeker's cognitive space and the context of IS&R, information seeker
and interface, information objects and IT and interface and the retrieval of information
objects by means of IT, manifested in query modification.

As the above model provides a generic picture of the relationships between the main
components of IS&R, the framework does not describe the nature of interactions in greater
detail. This is mainly due to that the model serves the ends of a research framework;
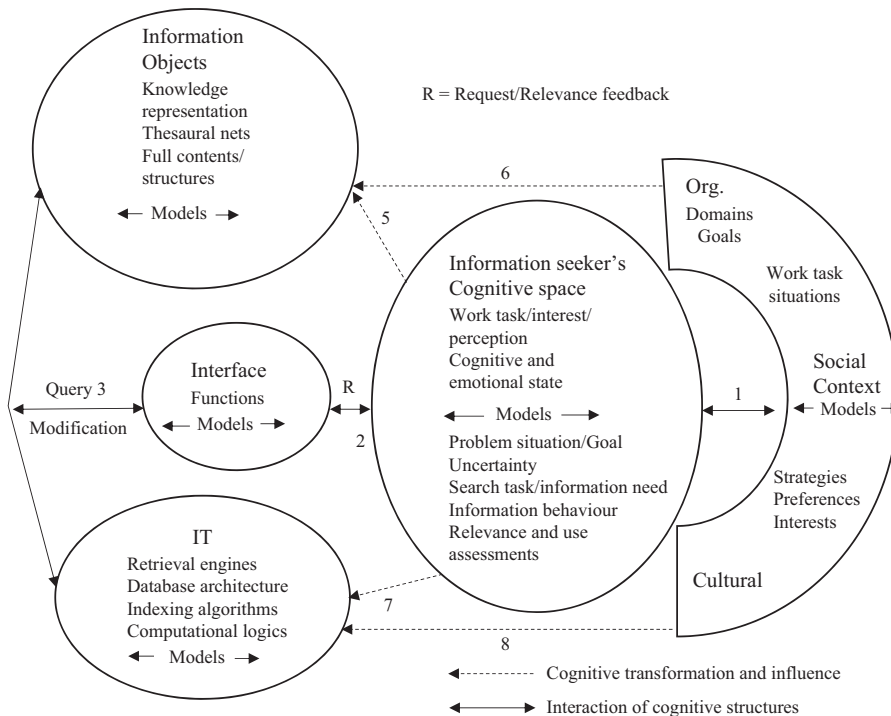
Source: Ingwersen and Järvelin (2005, p. 274)

the content of individual components and their relationships should be specified by conducting empirical studies. Moreover, the list of sub-components is not exhaustive because each component is represented by a selection of embedded cognitive structures. Therefore, an individual component may take a different form depending on the type of information objects, media and domain (Ingwersen and Järvelin, 2005, p. 275). Interestingly, the model devotes no particular attention to the role of human intermediaries. Similar to the ISSs framework (Belkin *et al.*, 1993), this reflects a shift of interest from intermediary-assisted searching to the setting in which an end user is expected to seek access to information resources by means of the information system.

The interaction between information seeker and the context of IS&R (arrow 1 in Figure 5) specifies a setting in which a host of factors constitutive of an individual's cognitive space, that is, his or her models of work task and problem situation at hand, as well as his or her perceptions of work task or interest in work task performance plus his or her goals, perceived uncertainty, cognitive and emotional state, perceived search task, information need and relevance assessments are shaped by organisational, social and cultural factors. From the perspective of the present study, however, interactions constitutive of the IR process are more pertinent. As explicated by Ingwersen and Järvelin (2005, p. 275), "interactive IR takes place, in particular via requests, information acquisition, relevance assessments and feedback". Interactions of the latter type occur when the information seeker seeks access to information objects by means of interface which enables the use of retrieval engines (arrows 2, 3 and 4 in Figure 5). Thus, the model suggests that interaction of this type is an integral element of the IR process, including query modification. Information interaction is oriented by the perceptions (models) that the information seeker has of the functions of the interface and information technological tools such as retrieval engines, and the nature of information objects, for example, the contents of documents of diverse types.

The nature of information interaction occurring during IR processes is described in most detail while characterising the interactive IR as a temporally sensitive phenomenon (Ingwersen and Järvelin, 2005, pp. 300-303). First, there can be short-term interaction with information sources, human or artifacts, understood as a few iterations including clarification of information need and probably relevance feedback. For example, information interaction is embedded in IR processes when a request of pointing at a graphical user interface (arrow 2 in Figure 5) is transformed into a query (arrow 3) that, by communication between a search engine and the information objects (arrow 4), entail a retrieval result communicated to the interface (3) (Ingwersen and Järvelin, 2005, p. 301). On the other hand, all short-term interactions are not based on the use of search engines. Social interaction within a work community exemplifies information interaction depicted by arrow 1 in Figure 5. For instance, an information seeker may ask advice from a colleague in a face-to-face discussion; in this case, information interaction is based on dialogue. Second, information interaction can appear in search sessions. The information seeker may change roles during a session, for instance, by a click of the mouse becoming an author, an indexer, a selector or database designer – again returning as an information seeker. Finally, there can be longitudinal IS&R interaction. A further prolonged IS&R activity may contain several sessions over a longer period of time, e.g., days, weeks or months. This is because information need situations tend to be highly dynamic and the factors giving rise to such needs, for example, work tasks may undergo alterations.

All in all, the above framework provides a sophisticated picture of the complex relationships between real stakeholders in IS&R processes and analyses their interaction. The model emphasises that all the participating cognitive structures are in context of all other cognitive components of the model. However, as Ingwersen and Järvelin (2005, pp. 262-263) reminded, this setting remains at quite a high level of conceptualisation.

This notion also concerns the characterisation of the generic construct of interaction and hence, a more specific construct of information interaction. As noted above, Ingwersen and Järvelin approached interaction as exchange between two or more contexts of actors and a two-way communication activity. This suggests that similar to other models reviewed above, the question about the fundamental nature of information interaction boils down to dialogue occurring between human actors or between human actor(s) and information system.

Discussion

The present study contributed to the information behaviour research by examining the conceptual space of phenomena related to information interaction – an umbrella term with multiple meanings. To achieve this, a conceptual analysis was made by concentrating on four pioneering models for interactive IS&R. To strengthen the focus of the study, the attention was directed to two modes of information interaction occurring between information seekers and human intermediaries, and users and information systems. The main findings are summarised in Table I.

The first research question dealt with the ways in which researchers have characterised interaction taking place between information seekers and human intermediaries. Interaction of this type is described in the models proposed by Belkin (1984) and Ingwersen (1996), while two other frameworks have not specified this issue. The former models share the fundamental idea of information interaction as a dialogue between human actors. Typically, the nature of dialogue is examined in the context of database searching process during which the intermediary assists in the specification of the information need and provides help in the selection of search terms. However, there are a few differences between the models. Belkin (1984) examined how the co-operative and goal-oriented dialogue progresses during the search, while Ingwersen's (1996) cognitive model approaches the user-intermediary interaction at a fairly general level. Interestingly, in an earlier study, Ingwersen (1982, pp. 178-182) examined the characteristics of the dialogue between librarians and users by devoting attention to the function of closed and open questions presented in the question-negotiation process. However, particular issues of this kind were not thematised in the models proposed by Ingwersen (1996) and Ingwersen and Järvelin (2005). This exemplifies the trend of declining interest in the questions of user-intermediary interaction, due to the growing popularity of searches performed by end users.

The second research question focussed on the characterisations of interaction between the information seeker (user) and information system. The models differed more in this regard, even though the early framework proposed by Belkin (1984) did not specify the nature of information interaction of this type. The ISSs framework (Belkin *et al.*, 1993) characterised at a general level how the user makes use of ideal typical methods of IR interaction, that is, searching for a known item or scanning. Later on, Belkin *et al.* (1995) made attempts to elaborate the ISSs model by identifying prototypical dialogue structures or scripts characteristic of diverse regions of ISSs space. The cognitive model developed by Ingwersen (1996) suggests that user-IR system interaction occurs when the cognitive space of the user interacts with IR systems and information objects, i.e., texts and documents. However, the nature of interaction of this kind remains open: what, in fact, happens when a user's cognitive space "interacts" with a text? User-information system interaction is characterised more exactly in the integrative model for IS&R (Ingwersen and Järvelin, 2005). Information interaction is inseparably embedded in the search process. Interaction of this type is constituted by diverse activities such as pointing at a graphical user interface in order to communicate with a search engine, with the intent of retrieving information objects from a database and assessing their relevance.

Finally, the third research question dealt with the main similarities and differences between the conceptualisations of information interaction. All four models reviewed in the present study approach the phenomena of information interaction from the cognitive viewpoint.

| | Models | | | |
Mode of information interaction	Model for cognitive communicative system (Belkin, 1984)	Model for information-seeking strategies (ISSs) (Belkin *et al.*, 1993)	The cognitive model for IR (Ingwersen, 1996)	The model for interactive information seeking and retrieval (Ingwersen and Järvelin, 2005)
Interaction between information seekers (users) and human intermediaries (RQ1)	Co-operative, goal-oriented dialogue based on the intermediary's cognitive model of the user and knowledge resources	Not specified	The feedback from the information system encourages the intermediary to present certain types of questions to the user particularly when the retrieved information objects do not provide the requested information	Not specified
Interaction between information seekers (users) and information systems (RQ2)	Not specified	Ideal typical methods of interaction: searching for a known item and scanning (Belkin *et al.*, 1993) Each region of ISSs space can be associated with a prototypical dialogue structures (scripts) in order to support IR systems design	The cognitive space of the user interacts with the IR systems and information objects, i.e., texts and documents	Information interaction is embedded in IR processes when a request of pointing at a graphical user interface is transformed into a query that, by communication between a search engine and the information objects, entail a retrieval result communicated to the interface
Main similarities between the models (RQ3)	The preference for the cognitive viewpoint The preference for a tripartite setting: information resources accessible through information systems, intermediary/interface, and user Approaching information interaction as dialogue between the actors (user and intermediary), or between user and the information system			
Main differences between the models (RQ3)	Belkin (1984): main emphasis laid on the intermediary-assisted searching Belkin *et al.* (1993): classificatory approach to the components of ISSs as interactions between the user and the IR system Ingwersen (1996): strong emphasis on interaction as acts of interactive communication of cognitive structures Ingwersen and Järvelin (2005): systematic approach to factors constitutive of information interaction in the context of information seeking and retrieval			

Table I.
Summary of the main research results

Except for the ISSs framework, common to the models is also the preference for a tripartite setting. The components of information resources/information objects (accessible through information systems) and users form the opposite ends, bridged by an intermediary or interface. The models also conceptualise dialogue as a fundamental factor of information interaction. The findings also indicate that each model emphasises different aspects of information interaction. Belkin's (1984) early framework devoted particular attention to the nature of human intermediary-assisted searching, while in the ISSs model proposed by Belkin *et al.* (1993), the interest was shifted to the identification of prototypical strategies for information seeking. Ingwersen's (1996) model for IR interaction differs from others by its strong emphasis on the role of human actor's mental models orienting information interaction.

Finally, the integrative model for IS&R proposed by Ingwersen and Järvelin (2005) exemplifies a systematic and generic approach to the study of diverse factors constitutive of information interaction.

Overall, the findings suggest that the models for information interaction have been refined markedly since the early 1980s. The evolution towards more systematic and elaborate frameworks is most clearly identifiable from the models proposed by Ingwersen (1992, 1996), culminating in the integrative model for IS&R (Ingwersen and Järvelin, 2005). Similarly, Belkin's models indicate successful attempts to elaborate the picture of information interaction, supported by empirical investigations testing the assumptions of these frameworks. On the other hand, the fact that the most sophisticated models for information interaction developed so far focus on intermediary-assisted searching or IR from databases suggests that the modelling of this phenomenon may be lagging behind the recent developments of IS&R. Currently, there is a number of models characterising diverse aspects of information seeking and searching (for an overview, see Case and Given, 2016, pp. 142-175), as well as the particular features of web searching (e.g. Pharo and Järvelin, 2004; Kinley *et al.*, 2014). Despite these contributions, we still lack models that would elaborate the nature of information interaction in the networked search environments. So far, thanks to its generic and technology-independent nature, the integrated model proposed by Ingwersen and Järvelin (2005) is best suited to this need. The above framework is hospitable to the analysis of interactive IS&R making use of information systems of diverse kind, including web search engines. However, a question remains about the applicability of the above model for the study of information interaction occurring in the forums of social media because the dialogue between the human actors is structured differently compared to database searching, for example.

Conclusion
Interaction is a multi-faceted construct and somewhat messy notion that is interpreted differently in diverse fields of study. Since the 1980s, the construct of information interaction has been used to depict a particular type of interaction taking place in the context of information behaviour. Similar to the concept of interaction, the construct of (human) information interaction has become a subject to multiple interpretations as a qualifier of IS&R. Drawing on an in-depth conceptual analysis of four key models, the present study highlights the fact that dialogue is a fundamental constituent of information interaction. Reflecting the developments in the field of IS&R, early models focussed on dialogue occurring in user-intermediary interaction, while more recent frameworks devote more attention to dialogue constitutive of user-information system interaction. As noted above, one of the challenges of the research community is to develop and empirically validate models of interaction that have dialogue as the central dynamic and are suitable for explaining phenomena in the current information systems environment.

As the present study was confined to the analysis of four pioneering models, the findings cannot provide any definite answer to questions such as what, in the final end, is information interaction, or what happens during the process of interaction of this kind? Given the generic nature of this umbrella concept, it is unlikely that it can ever be captured in an exact definition unanimously accepted by the research community. Nevertheless, to clarify the terminology of information behaviour research, it is important to delve deeper into the issues of information interaction so that this concept would have more discriminatory power in the future. Promising areas for the study of information interaction include, for example, collaborative IS&R because in this context, the role of interpersonal communication is particularly central. Moreover, the studies of the ways in which people make use of social media forums such as question and answering services may open new opportunities to deepen our understanding of information interaction as a mode of human action.

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