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# Research on Cross-Session and Cross-Device Search: A Systematic Literature Review

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**ABSTRACT** The complex process of online information search has been of great interest to academics and practitioners, regarding its motivation, triggers, phases, and various aspects of user search behavior. Web search spanning multiple sessions has been studied, including users switching between devices. The study presented in this paper aims to critically analyze two decades (2000 – 2020) of research on cross-session and cross-device search. A systematic literature review of 29 journal papers and peer reviewed academic conference proceedings was conducted. The main results were extracted, synthesized, and presented. Topical (focus and terminology), methodological (data collection, sample size, sample type, and countries studied) and bibliometric (publication outlet and citations) aspects of online information search were evaluated and described. The paper identifies keywords for effective literature searches and adds new insights about effective research methods and sampling, the most cited publications and most influential authors in this field and the possibility of conducting interdisciplinary research. Both scholars and practitioners can use this study to gain a deeper understanding of the cross-session and cross-device search research agenda. Future research suggestions inform researchers about issues that warrant further attention.

**INDEX TERMS** Cross-device search, cross-session search, information search, multi-session search, multi-screening, online information gathering.

## I. INTRODUCTION

The growth of the internet over the past decades resulted in a plethora of information about products and brands on websites and social networks. Users access online information resources to collect information relevant to their intended future purchase [1], [2]. A growing number of internet-connected devices is used due to the increased worldwide penetration of smartphones and tablets [3]–[5]. Search visibility for various type of content including images and video [6] has become of paramount importance for organizations and individuals, including influencers [7].

Researchers have been studying the information search behavior of users for some time. Research on online search and database searching goes back to the mid-1990s when the internet started to significantly impact business and society. The study of Bates [8], for example, investigates an evolving interactive online search within the context of a single search session. Kuhlthau [9] studied users'

perspectives on information seeking in context of information systems. Online information search became a focal point of researchers with the increased availability of the internet and the development of search engines. Lee and Lee [10] suggest that three variables contributed to the intensity and amount of information search, namely consumer ability, net benefits, and motivation. One of the directions of research focuses on online information search intensity and user behavior. This resulted in defining and using two well established terms that reflect how the information process works. These terms are 'cross-session search' and 'cross-device search'.

A study by Spink [11] can be considered the predecessor of cross-session search studies. Her research revealed that users engage in multiple search sessions over time, related to a variety of information problems. Nowadays, cross-session search is understood as using two or more search sessions to search for information related to the same topic or information problem. Users who engage in cross-session search therefore require more than one session to successfully conduct their information search. The length of session typically varies between 20 minutes [12] and 90 minutes [13]. The end

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of session is usually marked by a change in activity and focus of the user. When starting their next session, users utilize the knowledge from the previous session(s) and use strategies to retrieve some of the search results they considered earlier.

Researchers also study cross-device search where more devices are used to search for information, e.g. smartphone, tablet, laptop, desktop computer, smart TV. The device transition, i.e. the behavior of changing devices when searching, is an indispensable feature of the cross-device search [14]. The next search session can therefore either continue with the same device, or another device can be used. Cross-device search can also be defined as searching on different devices for the same topic [14] or a combination of an anterior device, a posterior device, a pre-switch session, a post-switch session and queries in both sessions [15]. The boundaries between cross-session and cross-device search start to fade at this point and cross-session search can also become a cross-device search. An extensive Google study [16] refers to the current environment as the ‘multi-screen world’, where multiple devices are often using in the information search process.

The research on cross-session and cross-device search is well established in the Information Systems (IS) and Information Technology (IT) academic communities. Researchers are examining various aspects of this phenomenon, to understand which terms are often researched, how a next session connects to the previous one or how the transition is made from one device to another. Application of the research findings mostly focuses on search algorithms and search engines – i.e. ways to optimize their usability and functions - while assisting users in accomplishing their search tasks efficiently. However, the implications of the research on cross-session and cross-device information search go beyond the IS and IT fields. It has been well established that being visible when people search for product and/or company-related information is crucial for businesses [17], especially when digital transformation reshapes the way they operate [18]. Therefore, understanding the unique characteristics of cross-session and cross-device search and nuances of the search process is just as relevant for IS and IT as it is for business and marketing academics and practitioners.

In this article, we aim to critically analyze two decades’ (2000 – 2020) research on cross-session and cross-device search and extract interdisciplinary implications of these phenomena. This time period was selected because the research in the field started after 2000. Most of the consumer information search literature is found in the fields of marketing and psychology [1]. We therefore consider it essential to ensure that the results of research on cross-session and cross-device search - which are primarily oriented at the IS and IT community - become interdisciplinary, as well as acknowledged and used by the community of business and marketing academics and practitioners.

## II. OBJECTIVES OF THE STUDY

In this paper we reviewed empirical and theoretical studies about cross-session and cross-device search that were

published between 2000 and 2020. A plethora of research studies focus on user search behavior across multiple sessions and devices. More studies focus on cross-session search than cross-device search. Furthermore, apart from ‘cross-session search’ a variety of other terms are used to describe user search behavior spanning multiple sessions. In the case of cross-device search, the terminology is more consistent and no other terms are used to describe user searches on different devices.

The objective of this research was to identify the variety of terms used in the cross-session research area and the topics examined, to create a comprehensive overview of methodologies and research samples used, to identify influential publications, to extract the broader implications of the current research and, based on the research gap, suggest topics for future research in the area of cross-session and cross-device search.

The research questions we address are:

*RQ1:* How has the terminology related to cross-session search evolved over time?

*RQ2:* What are the focus areas of the research on cross-session and cross-device search?

*RQ3:* What are the characteristics of the samples used and which methodologies prevail in the current research?

*RQ4:* What are the most influential publications, based on the number of citations?

*RQ5:* What are the broader implications of the research on cross-session and cross-device search?

*RQ6:* What are the potential directions for future research in this area?

## III. METHODOLOGY

A systematic literature review was deemed appropriate to achieve the objectives of this research [19]. To answer the defined research questions, relevant keywords were included in the search string to identify resources dealing with the issues of cross-session search and cross-device search. The keywords used in the search string were iteratively developed, starting with the terms ‘cross-session search’ and ‘cross-device search’. After assessing the results, identifying the relevant resources and evaluating them, other terms were added into the search string. The terms were based on the terminology used in these resources to describe the phenomena that are in the focus of this literature review. More details on the terminology used are provided in section IV.A.

The PRISMA flow diagram (Fig. 1) depicts the flow of information through the different phases of this systematic literature review.

The online databases that were used to identify and access relevant literature is Web of Science, SCOPUS, Wiley Online Library, and ACM Digital Library. The first author retrieved the papers and documented the source of the paper, language, main area, research methods, and implications. The second author reviewed the result of the selection and documenting. The list of papers was created by searching these databases and following up the references in the identified papers.

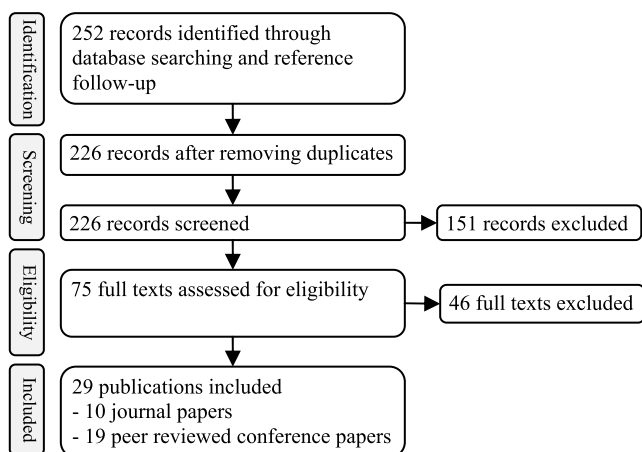


FIGURE 1. PRISMA flow diagram.

The list consisted of 252 publications, which was narrowed down to 226 publications by removing duplicate papers (e.g. similar papers published in both a journal and conference proceedings, or the same paper published in various sources).

Inclusion and exclusion criteria were applied to select the literature that is most relevant to the studied area. Only papers closely related to either cross-session search or cross-device search were included. Papers that focused too broadly (e.g. on various aspects of multi-device and multi-screen environment) were excluded. By applying this selection process, the number of resources were narrowed down to 75 relevant papers. These were reviewed and thoroughly evaluated.

Only high-quality papers (language, methodology, outputs) were retained. Books book chapters, doctoral dissertation theses, papers from symposiums, workshops or short presentations were excluded. These decisions were made by consensus between the authors. Based on the consensus of the first two authors, the list of papers was narrowed down. The third author performed quality control and served as a mediator in case dispute resolution was required. As a result of this process, a final sample of 29 articles published between 2000 and 2020 was selected. The original intent to include only journal articles in this literature review had to be revised, as a significant part of the research on cross-session search and cross-device search was published in conference proceedings. Only full conference papers, not abstracts, were included in the research sample.

To eliminate potential bias, the authors formulated key characteristics of the review before starting the work. The literature review was guided by six research questions. Involving the third author in the discussions and design of the research framework also helped eliminate the risk of bias as he does not specialize in information search behavior and could therefore intervene if any intrinsic knowledge and preconceived ideas of the first two authors might influence the research design and outcomes.

Of the 29 papers, 10 were published in journals and 19 in peer reviewed academic conference proceedings. Most of journal articles ( $n = 6$ ) are published in The Journal

of the American Society for Information Science and Technology while the four remaining journals published one paper each. The Conference on Research and Development in Information Retrieval (SIGIR) was the most popular, featuring 6 papers in its proceedings ( $n = 6$ ), followed by the Conference on Human Information Interaction and Retrieval ( $n = 2$ ). Each of the remaining 11 papers was published in different conference proceedings. Details are shown in Table 1.

A protocol used by Hao *et al.* [19] was adapted for the purpose of this study, due to its complex character. The protocol was designed to collect and evaluate data on i) research focus and design (research type and terminology used); ii) methodology (data collection, sample size, sample type, and countries studied); and iii) bibliometric aspects (publication outlet and citations). A narrative approach was adopted to investigate this research domain. A similar methodology was used in a study on systems developed and technologies used for smart homes by Sepasgozar *et al.* [20], in which they i) reviewed relevant papers published between 2010 and 2019, within databases such as Scopus, ii) analyzed the papers in terms of bibliography and content to identify more related systems, practices, and contributors, iii) used a systematic review method to identify and select the relevant papers and iv) reviewed the content of the relevant papers by means of coding.

#### IV. FINDINGS

The review started by classifying previous research according to its focus, i.e. either cross-session search or cross-device search. For cross-session search, details of other terminology used were also included. The review also focused on methodological aspects employed (data collection, sample size, sample type, and countries studied), and the bibliometric aspects (publication outlet and citations) included in previous studies.

##### A. RESEARCH FOCUS AND TERMINOLOGY

###### 1) CROSS-SESSION SEARCH

The study by Lin and Belkin [21] can be regarded as the pioneer in cross-session research. This study uses the term ‘multiple information seeking episodes (MISE)’ to describe cross-session search behavior. Their original model consists of four dimensions: i) situation; ii) information problem; iii) search process; and iv) episodes. The full-text of the Lin and Belkin study [21] could not be retrieved, but the model was later validated by Lin and Belkin [22] and this study is included in this literature review. Spink *et al.* [24] posit that successive searching may be motivated by a series of information problems arising from a substantive research problem. They also mention that related and successive searches can be performed within different sessions. Lin [25] continued the work on MISE, using terms such as ‘successive information searches’ or ‘multiple search sessions’. Lin and Belkin [22] expanded their original MISE model and validated modes of information search to include search through

**TABLE 1. Journals and conference proceedings in the research sample.**

Source title	Source type	Number of articles	References	Percentage of total (%)
Journal of the American Society for Information Science and Technology	Journal	6	Spink et al. (2002), Lin and Belkin (2005), Lin (2005), MacKay and Watters (2012), Sahib et al. (2014), Wu et al. (2020)	20.69
Conference on Research and Development in Information Retrieval (SIGIR)	Conference	6	Liu and Belkin (2010), Kotov (2011), Agichtein et al. (2012), Bron et al. (2013), Qvarfordt et al. (2014), Wu et al. (2018)	20.69
Conference on Human Information Interaction and Retrieval (CHIIR)	Conference	3	Li (2020), Li et al. (2020), Liu et al. (2020)	10.35
Proceedings of the ASIST Annual Meeting	Journal	1	Alhenshiri et al. (2012)	3.45
ACM Transactions on Information Systems	Journal	1	Han et al. (2015)	3.45
Proceedings of the Association for Information Science and Technology	Journal	1	Han et al. (2017)	3.45
Information Processing & Management	Journal	1	Wu et al. (2019)	3.45
Conference on Human Factors in Computing Systems	Conference	1	Morris et al. (2008)	3.45
International Conference on Knowledge Discovery and Information Retrieval (KDIR)	Conference	1	Alhenshiri et al. (2010)	3.45
Conference on Human Factors in Computing Systems (SIGCHI)	Conference	1	Capra et al. (2010)	3.45
Conference on Information Systems (AMCIS)	Conference	1	Lin (2010)	3.45
ACM International Conference Proceeding Series	Conference	1	Tyler and Zhang (2012)	3.45
Conference on Open Research Areas in Information Retrieval	Conference	1	Hagen et al. (2013)	3.45
International Conference on World Wide Web	Conference	1	H. Wang et al. (2013)	3.45
ACM International Conference on Information and Knowledge Management (CIKM)	Conference	1	Awadallah et al. (2014)	3.45
ACM International Conference on Web Search and Data Mining	Conference	1	Y. Wang et al. (2013)	3.45
ACM International Conference on Conference on Information and Knowledge Management	Conference	1	Montanez et al. (2014)	3.45

multiple sessions. They add terms such as ‘successive information searches’ and ‘multiple search sessions’. In this very detailed work, they define various internal and external factors that will interrupt the search and eight reasons to resume the search. Although they still refer to their MISE model, the term ‘multiple search sessions’ is used in the article title.

Multi-session search tasks were also studied by Morris *et al.* [26]. They reveal the strategies employed by users of status-quo tools for handling multi-query and multi-session search tasks. They also introduce SearchBar, a tool supporting multi-session investigations by assisting with task context resumption and information re-finding. The paper by Liu and Belkin [27] predicts the usefulness of retrieved documents over the course of several information seeking episodes. In his 2010 paper, Lin [28] introduces another related term, namely ‘successive multi-session web searches’. Similarly, Alhenshiri *et al.* [29] use the term ‘multi-session information gathering tasks’, recognizing that information gathering on the web often requires several sessions. They summarize some of the research that deals with preserving and re-finding information, which is typically required by search tasks lasting multiple sessions. Multi-session search tasks are also central to the paper by Capra *et al.* [30], which identifies the issues that users face in re-finding information in multiple-session search.

In 2011, another study on user search behavior over multiple sessions was published, this time using the term

‘cross-session search’ [31]. The authors aim to understand the complexity of information search tasks and user behavior in cross-session tasks. They focus on identification of similar/interconnected search queries and predict the return of the user to the search task in future. Agichtein *et al.* [32] investigated the understanding and predicting of search task continuation. Their study about interrupted search tasks adopts the early classification of top level search tasks, created by Rose and Levinson [33]. Three groups of search intent are defined, namely i) informational; ii) navigational; and iii) transactional search tasks. Alhenshiri *et al.* [34] tested the features of WIGI, a prototype tool that helps users with managing information search tasks that last multiple sessions. They focus on permitting users to i) track references opened during information gathering sessions; and to ii) re-find integrated task information. MacKay and Watters [35] use the term ‘multisession web tasks’ and categorize them into ‘expected’ and ‘unexpected’. They aim to describe the types of tasks that people perform on the web, in particular those who require more than one web session and where search is an intrinsic part of the tasks Tyler and Zhang [36] investigated re-searching (finding an information that has previously been obtained) from a multi-session search perspective. They found it diversity exists even amidst repeated re-findings of users and that the behavior for many re-search queries differs from the original search Hagen *et al.* [13] elaborate on the idea of search intent detection, resulting in the use of the term ‘search mission’.

**TABLE 2.** Cross-session search terminology in the literature.

Terminology	Number of studies	References
Cross-session search	6	Kotov (2011), Agichtein <i>et al.</i> (2012), H. Wang <i>et al.</i> (2013), Sahib <i>et al.</i> (2014), Li <i>et al.</i> (2020), Li (2020)
Multiple information seeking episodes	3	Lin and Belkin (2005), Lin (2005), Liu and Belkin (2010)
Multi-session search	2	Morris, Capra <i>et al.</i> (2010), Tyler and Zhang (2012)
Multi-session search tasks	2	Morris and Venolia (2008), Bron <i>et al.</i> (2013)
Successive searches	1	Spink <i>et al.</i> (2002)
Successive multi-session web searches	1	Lin (2010)
Multi-session information gathering tasks	1	Alhenshiri <i>et al.</i> (2010)
Multiple session search tasks	1	Alhenshiri <i>et al.</i> (2012)
Multisession web tasks	1	MacKay and Watters (2012)
Multiple logical search sessions	1	Hagen <i>et al.</i> (2013)
Search tasks spanning multiple sessions	1	Awadallah <i>et al.</i> (2014)
Re-finding search sessions	1	Qvarfordt <i>et al.</i> (2014)
Multi-round search iterations	1	Liu, Sarkar and Shah (2020)

\* The main term used was selected in case of multiple terms used in the paper

According to them, search missions consist of multiple logical search sessions that are characterized by multitasking and hierarchical objectives. The next research paper published in 2013 [12] also presents results aimed at identifying search missions or search tasks. In the database (search log), they created sessions based on the 20-minute time span, but also grouped keywords/sessions based on the search task. Thus, they studied how the search tasks are intertwined with search sessions and sometimes multiple sessions are needed to accomplish the search task. However, one session can be used to conduct research on various topics belonging to different search tasks. The work of Bron *et al.* [37] focuses on studying the preferred search interface for users performing complex multi-session search tasks. Also dealing with multi-session search tasks, Sahib *et al.* [38] investigated the behavior of visually impaired users. They discuss the strategies for resuming search, accessing previously reviewed information, and compare information seeking behaviors across two sessions. Awadallah *et al.* [39] also deal with complex search tasks than can span multiple sessions. They propose a system to build a graph connecting multiple tasks together, which is useful to assist new searchers while exploring new search topics or tackling multi-step search tasks. The paper of Qvarfordt *et al.* [40] deals with complex informational search. Despite not specifically referring to cross-session search, it deals with helping users with information re-finding, classifying some search sessions as re-finding sessions.

One of the latest studies on cross-session search [41] focuses on how users search across multiple sessions and their motivation for doing so. The researchers found that most search tasks are cognitively very complex. Apart from evaluating search results and adjusting the search phrases, they also require consulting with another person/party Li [42] also acknowledges that search across more sessions has challenging characteristics, and that many studies have already tried to develop tools to support cross-session search. In her work, she focusses on how and why people search across

sessions. As one of the key results, Li [42] identifies the most common task-related session stopping- and renewal reasons for the most recent search session, by referencing back to Lin and Belkin's eight renewal modes [22]. In another 2020 study, Liu *et al.* [43] recognize that multi-round search iterations are integral to everyday learning, work, and problem solving. In their research, they explored the dynamic nature of complex search tasks from a process-oriented perspective by identifying and predicting implicit task states. Table 2 presents the terminology used.

The research focus and research implications/contributions of cross-session search studies are summarized in Table 3.

## 2) CROSS-DEVICE SEARCH

Previous studies investigated search tasks spanning multiple sessions without considering the device switch, or they examined mobile and desktop searches separately. The study of Y. Wang *et al.* [15] is unique in the sense that it focuses on cross-device search, i.e. web search in context of the transition from desktop computers/laptops to mobile devices and vice versa. Wang characterizes the nature of cross-device search tasks, with its implications centred around search engines. The study claims that search tasks are complex and often involve multiple queries across multiple sessions and devices. The authors acknowledge that it can be quite challenging for users to switch between devices to continue their search tasks. The common solution for this, namely sharing the search history between devices, has several limitations. For example, users must remember what they were searching for and what information they have already found. In line with Y. Wang *et al.* [15], the study by Montanez *et al.* [44] stresses that understanding the use of multiple devices such as computers, laptops, and smartphones for information search are essential. The authors focus on creating models predicting various aspects of cross-device search, for example the next device used for search. The aim of their research is to empower search engines to provide more direct support for various applications, including search continuation.

**TABLE 3. Summary of studies on cross-session search.**

Citation	Major research focus	Implications/Findings
Spink <i>et al.</i> (2002)	Information seeking process, stages of information research	A theoretical framework encompassing the actions taken by information-seekers in their search for information, including the actions involved in the interactive search process, and changes that take place over time in the problem stage
Lin and Belkin (2005)	Validation of the original MISE model	Eight modes of multiple information seeking episodes are identified and specified with properties of the four dimensions of MISE; the revised MISE model is shifted from the user-centred to the interaction-centred perspective
Lin (2005)	Evolution of the MISE model factors, introduction of additional factors into MISE	Better understanding of search processes over multiple information seeking episodes, including factors associated with searchers, search activity, search context, systems, information attainment, and information use activities
Morris <i>et al.</i> (2008)	Study user behaviour by multi-session search tasks	Revealed the strategies employed by users of status-quo tools for handling multi-query, multi-session search tasks; introduced SearchBar, a tool supporting multi-session investigations by assisting with task context resumption and information re-finding.
Alhenshiri <i>et al.</i> (2010)	Identifying subtasks of the underlying information gathering tasks	Summary of research dealing with preserving and re-finding information which is typically required by search tasks lasting multiple sessions
Capra <i>et al.</i> (2010)	Understand problem-centred searching in multiple sessions in collaboration with other stakeholders	Despite technological development, users are still dealing with the same issues (e.g. how to save/organize/manage/re-find found information) and are using many of the same strategies
Lin (2010)	Determine how the behavioural characteristics of the searchers evolve over sessions	Validating a theoretical model in explaining successive searches and helping revise system requirements for supporting the concerned search behaviour.
Liu and Belkin (2010)	Predicting usefulness of retrieved documents over the course of several information seeking episode	Increasing accuracy in predicting document usefulness and accordingly in personalizing search for multi-session tasks.
Kotov (2011)	Understand the complexity of information search tasks and user behaviour in cross-session tasks	Identification of similar/interconnected search queries and predicting the return of user to the search task in the future.
Agichtein <i>et al.</i> (2012)	Understanding and predicting of the search task continuation	Search task prediction method. significantly outperforming both a state-of-the-art baseline and predictions based on human judgments.
Alhenshiri <i>et al.</i> (2012)	Characterising three subtasks of information gathering tasks	Testing the differences in user behaviour using MS Explorer browser and the WIGI experimental tool for search tasks
MacKay and Watters (2012)	Understanding what types of tasks, requiring more than one session, are common with users	Eight different types of multisession tasks were identified, along with unique strategies to help users continue the tasks which involved a variety of web and browser tools such as search engines and bookmarks and external applications
Tyler and Zhang (2012)	Re-searching - finding an information that has previously been obtained	Diversity exists even amidst repeated re-findings users and that the behaviour for many re-search queries differs from the original one
Bron <i>et al.</i> (2013)	Studying the preferred search interface for users performing complex search tasks	Stable information need over multiple sub-tasks negatively influences perceived usability of the blended displays, while there is no influence when the information needs change
Hagen <i>et al.</i> (2013)	Search missions: Detecting user search intent	Search missions consists of multiple logical search sessions and are characterised by multitasking and hierarchical objectives
H. Wang <i>et al.</i> (2013)	Identifying search tasks and search missions	How search tasks are intertwined with search sessions and sometimes multiple sessions are needed to accomplish the search task but also one session can be used to research on various topics belonging to different search tasks
Awadallah <i>et al.</i> (2014)	Studying complex search tasks than can span multiple sessions	Proposition of a system to build graph connecting multiple tasks together and use it to assist new searchers in exploring new search topics or tackling multi-step search tasks
Qvarfordt <i>et al.</i> (2014)	Supporting users in their ongoing information seeking	A SearchPanel browser extension was developed and tested to compensate for deficiencies in traditional search result pages regarding re-finding and exploratory search activities
Sahib <i>et al.</i> (2014)	Behaviour of visually impaired users dealing with multi-session search tasks	Implications for the design of tools to support searchers to manage and make sense of information during multi-session search tasks
Li (2020)	How and why people search across multiple sessions	Identification of the most common task-related session stopping reasons and renewal reasons for the most recent search session
Li <i>et al.</i> (2020)	How and why people search across multiple sessions	Most search tasks were highly cognitively complex and on top of evaluating search results and adjusting the search phrases they also required consulting with another person/party
Liu <i>et al.</i> (2020)	Explore the dynamic nature of complex search tasks from process-oriented perspective	Identifying and predicting implicit task states

The paper by Han *et al.* [45] emphasizes that search can be initiated on mobile devices at any time and in any place. However, because of the relatively small screen and

other constraints, some of the more complex queries can be difficult to handle on mobile devices. Similar to the two previous studies [15], [44], the authors focus on studying web

**TABLE 4.** Summary of studies on cross-device search.

Citation	Major research focus	Implications/Findings
Y. Wang <i>et al.</i> (2013)	Transition from desktop computers/laptops to mobile devices and vice versa by web search	Characterises the nature of cross-device search tasks, with its implications centred around search engines
Montanez <i>et al.</i> (2014)	Understanding the use of multiple devices such as computers, laptops, and smartphones for information search	Empowering search engines by creating models predicting various aspects of cross-device search, for example the next device used for search
Han <i>et al.</i> (2015)	Examine cross-device search behaviour from the perspective of device constraints	Differences between the cross-device web search and same-device cross-session web search identified, in terms of information exploration, sense-making activities, and repeated behaviours
Han <i>et al.</i> (2017)	User behaviour by both initial and continued sessions	Comparing both mobile-to-desktop (M-D) and desktop-to-desktop (D-D) conditions
Wu <i>et al.</i> (2018)	Information resumption behaviours	Identifies four important issues in relation to modelling the information resumption behaviour
Wu <i>et al.</i> (2019)	Real user experience with cross-device search	Identifying and studying five reasons for device switch, connecting it back to the original MISE (multiple information seeking episodes) model
Wu <i>et al.</i> (2020)	Two phases of cross-device search behaviour	Information need remains blurred in task preparation and becomes clear in task resumption

search tasks involving long search sessions with a number of queries. However, unlike the two previous studies, [45] conducted a user study to shed more light on the issues of cross-device search. To understand and model the mobile-to-desktop (M-D) cross-device search patterns, Han *et al.* [46] apply the widely adopted HMM (Hidden Markov Model) machine learning technique.

The study by Wu *et al.* [14] builds on the previous research on cross-device search and specifically addresses information resumption behaviors. Four important issues related to modeling the information resumption behavior has been identified: i) the pre-switch user experience influences the post-switch session information resumption, i.e. the long-term exploration of the issue across multiple devices increasing users' knowledge; ii) queries are optimized when switching between devices, based on lessons learned from previous searches; iii) the number of effective queries is also influenced by the fact that search queries evolve/are optimized in time; iv) the click rate of the post-switch session is affected by the previous experience, with users focusing on result areas based on their knowledge Wu *et al.* [48] examined cross-device search from the real user experience point of view. Five reasons for device switch are described, with i) unsatisfied and ii) complement (looking for additional information) dominating the answers, followed by iii) planned (users intended to switch the device), iv) forced (they could not continue the search for various reasons) or v) memory (to remember what they found). In another study, Wu *et al.* [49] describe the cross-device search behavior as consisting of two phases: i) task preparation, and ii) task resumption. The authors regard re-finding information not only as looking for the same information (a query or a URL), but also as finding new or additional information on the same topic. The findings reveal that information need remains blurred in task preparation and becomes clear in task resumption. Interruption caused by device transition leads to the phenomenon of re-finding in cross-device search. This research is novel because studies of re-finding usually consider resuming, instead of investigating how users

**TABLE 5.** Countries of focus.

Target country examined	Frequency	Percentage of total (%)
USA	14	56
China	4	16
Canada	2	8
UK	1	4
Netherlands	1	4
India	1	4
Iceland	1	4
Serbia	1	4
Total	25	100

\* 20 studies disclosed sample subject's country; three studies contained subjects from more than 1 country

searched before resuming the task. Major research focus of cross-device search studies and their research implications/contributions are summarized in Table 4.

## B. RESEARCH SAMPLE AND METHODOLOGIES

### 1) RESEARCH SAMPLE DETAILS

Table 5 summarizes the country frequency and percentage of the 20 studies for which the country was disclosed.

The results of the sample type and sample size analysis are listed in Table 6. Two studies were omitted from this analysis. Alhenshri *et al.* [29] was not included as it used secondary data and Qvarfordt *et al.* [40] does not disclose details of the sample.

### 2) MAIN METHODOLOGIES USED IN THE LITERATURE

The frequencies of methodologies used in the analyzed studies are listed in Table 7.

Experiments include laboratory-, hybrid-controlled-, and classifications experiments. Query log analysis refers to analyzing query logs, i.e. the lists of entries containing search phrases along with associated information. With mixed method research, multiple methods are used consequently to find answers to research goals. Survey represents the use of quantitative questionnaires, while secondary data refers to analysis of existing data and documents that have previously been gathered for a different purpose.

**TABLE 6. Sample type and sample size.**

Author	Sample type	Sample size
Spink et al. (2002)	University staff	198
Lin and Belkin (2005)	University students	20
Lin (2005)	University students	20
Morris et al. (2008)	Diverse	16
	University staff and students	
Capra et al. (2010)		30
Lin (2010)	University students	20
Liu and Belkin (2010)	University students	24
Kotov (2011)	Query log	270,470
Agichtein et al. (2012)	Query log	1,191
Alhenshiri et al. (2012)	University students	30
MacKay and Watters (2012)	University students and staff	22; 24*
		62; 650,000;
		5,000,000**
Tyler and Zhang (2012)	Diverse	5,000,000**
Bron et al. (2013)	University students	44
Hagen et al. (2013)	Diverse	127
H. Wang et al. (2013)	Diverse	7,628
Y. Wang et al. (2013)	Undisclosed	39,081
		Hundreds of thousands
		search sessions
Awadallah et al. (2014)	Diverse	1,675,272
Montanez et al. (2014)	Undisclosed	
Sahib et al. (2014)	Diverse	12
Han et al. (2015)	University students	24
Han et al. (2017)	University students	24
Wu et al. (2018)	University students	34
Wu et al. (2019)	Diverse	343
Li (2020)	Diverse	110
Li et al. (2020)	Diverse	110
Liu et al. (2020)	University students	40
Wu et al. (2020)	University students	34

\* 22 - Diary study; 24 - Field study

\*\* 62 - Survey; 650,000 - English search log; 5,000,000 - Chinese search log

**TABLE 7. Main methodologies used.**

Main methodology	No. of articles	References	Percentage of total (%)
Experiment	14	Lin and Belkin (2005), Lin (2005), Morris et al. (2008), Lin (2010), Liu and Belkin (2010), Alhenshiri et al. (2012), Bron et al. (2013), Awadallah et al. (2014), Sahib et al. (2014), Han et al. (2015), Han et al. (2017), Wu et al. (2018), Liu et al. (2020), Wu et al. (2020)	48
Query log analysis	5	Kotov (2011), Agichtein et al. (2012), Hagen et al. (2013), Y. Wang et al. (2013), Montanez et al. (2014)	17
Mixed method	4	MacKay and Watters (2012), Tyler and Zhang (2012), H. Wang et al. (2013), Qvarfordt et al. (2014)	14
Survey	3	Li (2020), Li et al. (2020), Wu, Dong and Liu (2019)	10
Interview	2	Spink et al. (2002), Capra et al. (2010)	7
Secondary data	1	Alhenshiri et al. (2010)	3
Total	29		100

**C. CITATION ANALYSIS**

The influence of academic work is assessed using citation count [50]. Google Scholar citations are used to determine the total number of citations. Subsequently, annual average number of citations is reported for every publication. The 20 most cited papers are shown in Table 8, ranked in ascending order by citations per year.

**TABLE 8. Citation analysis of papers on cross-session and cross-device search.**

Authors	Type of article	Citation count	Citations per year
Kotov (2011)	Conference paper	163	18
Morris et al. (2008)	Conference paper	158	13
Liu and Belkin (2010)	Conference paper	121	12
H. Wang et al. (2013)	Conference paper	83	12
Agichtein et al. (2012)	Conference paper	79	10
Montanez et al. (2014)	Conference paper	54	9
Awadallah et al. (2014)	Conference paper	52	9
Spink et al. (2002)	Journal paper	140	8
Y. Wang et al. (2013)	Conference paper	45	6
Capra et al. (2010)	Conference paper	59	6
Han et al. (2015)	Journal paper	29	6
Bron et al. (2013)	Conference paper	36	5
Hagen et al. (2013)	Conference paper	29	4
Lin and Belkin (2005)	Journal paper	51	3
Sahib et al. (2014)	Journal paper	14	2
MacKay and Watters (2012)	Journal paper	13	2
Alhenshiri et al. (2010)	Conference paper	14	1
Qvarfordt et al. (2014)	Conference paper	8	1
Lin (2005)	Journal paper	10	1
Tyler and Zhang (2012)	Conference paper	5	1

\* Only papers with 5 or more citations were included

\*\* Citation count source: Google Scholar; date recorded: 01 Aug 2020

**V. DISCUSSION**

In this section we indicate how the research questions are addressed.

**A. TERMINOLOGY USED**

The first research question (*RQ1*) refers to the evolving terminology related to cross-session search over time. Thirteen different terms are used in the analyzed papers on cross-session search. Spink [11] introduced the multiple search session model and later uses the term successive searches [23]. Following this, a further 11 terms are used by researchers studying the cross-session search phenomenon. Although subtle differences exist between these terms, they all refer to the same behavior of users searching for information over multiple, successive search sessions. The changes in terminology can be explained by i) the evolving understanding of the nature of cross-session search, also connected to the developments in technology; ii) the various angles the researchers investigated or emphasized. Some of the most similar terms can be grouped to reduce the number of terms used. A few possible criteria can be used for grouping. For example, by applying the linguistic principle the terms multi-session search, multi-session search tasks, and multiple session search tasks can be used interchangeably, as they all refer to the same phenomenon and use the same terminology (multi-session; multiple sessions). Another approach to grouping may focus on the perspective of the studies. Researchers using the terms multi-session search tasks, multi-session information gathering tasks, multiple session search tasks, multisession web tasks, and search tasks spanning multiple sessions approached the cross-session search by investigating how users need more search sessions to accomplish the search tasks. The term ‘cross-session search’ is used most frequently in studies (six, including the most



recent ones). More details on the terminology used in the literature can be found in Table 2.

### B. FOCUS OF THE RESEARCH

The second research question (*RQ2*) deals with the focus areas of the research on cross-session and cross-device search. Previous research clarifies different aspects of user behavior by multi-session and multi-device search. Researchers describe the search intent or motivation of users to search within multiple sessions, referred to as search missions or high-level search tasks. Researchers try to group sessions, or assign search queries to search tasks on a more granular level. Researchers also predict the chance of user returning to his search mission in another session. To make the prediction this, keywords were analyzed and the development/modification of the information problem within the search was studied. Apart from manual annotations, algorithms including machine learning techniques were used to analyze data and provide reliable annotations and categorization of extensive search logs.

The other main topic analyzed is user strategies for reusing the knowledge learned in previous sessions. When starting the next session (successive search session), users deploy various strategies of accessing the resources they found before, sometimes referred to as re-searching or information re-finding. Some of the research studies tested various tools, such as browser extensions or applications extending the functionality of commercial search engines by allowing users to annotate results, save them, etc., to assist them in effectively accomplishing their search tasks. Thus, the main implications of the reviewed studies are often centred around developing better algorithms or search engine user interfaces.

In cross-device search, researchers studied various aspects of the transition between devices while searching for information. They investigated the probabilities of switching devices as part of the same search mission and explain why these transitions happen. Researchers also predict the next device used for search. It has been confirmed that search is the primary tool for re-finding information on another device and thus, is essential for successful accomplishment of search tasks. The development and optimization of search queries when switching devices has been studied.

More details on the focus of the research on cross-session and cross-device search are provided in tables 3 and 4.

### C. SAMPLE AND METHODOLOGIES

The third research question (*RQ3*) prompted the investigation of the characteristics of the samples used and prevailing methodologies in the literature. The samples consisted mostly (61 percent) of users from the USA, followed by China (17 percent), and Canada (9 percent). UK, Netherlands, and India each accounted for 4 percent of the sample.

Of the 27 studies included in the sample type and size analysis, 52 percent used a sample of university students and/or staff. Although this has been a common and legitimate approach to sampling, due to the proximity and availability of

these research participants, the validity and generalizability of these results is partially affected. With regards to sample size,  $n < 100$  for 51.9 percent of the articles,  $n$  lies between 100 and 1000 for 29.6 percent, and  $n > 1000$  for 18.5 percent of the articles. There is a large range in sample sizes, with smallest size  $n = 12$ , and largest size  $n = 5,000,000$ . It is worth noting that the difference in sample sizes may also be influenced by the data collection methods. For example, the sample size of a user study is usually smaller than that of search engine logs. The overview of sample sizes in Table 6 gives researchers who would like to contribute to the field a quick overview of how other researchers made decisions about sample sizes. This can help them select an optimal sample size for their research project to respect the conventions and/or to employ research design allowing for direct comparison of their data with one or more of the previous studies.

Experiment is the most frequent method used in 48 percent of papers, followed by query log analysis (17 percent), mixed methods (14 percent), survey (10 percent), interview (7 percent) and secondary data analysis (3 percent).

### D. INFLUENTIAL SOURCES

Answering the fourth research question (*RQ4*) required identifying the most influential publications, based on the number of citations. The five most cited papers (lifetime) are Kotov (2011) with 163 citations, Morris *et al.* (2008) with 158 citations, Spink *et al.* (2002) with 140 citations, Liu and Belkin (2010) with 121 citations, and H. Wang *et al.* (2013) with 83 citations. The five papers with the highest annual average of citations are: Kotov (2011) with 18 citations per year, Morris *et al.* (2008) with 13 citations per year, Liu and Belkin (2010) with 12 citations per year, H. Wang *et al.* (2013) with 12 citations per year, and Agichtein *et al.* (2012) with 10 citations per year. By identifying sources with high numbers of citations, researchers can save time by only studying literature that had a significant impact based on the quality of the research, its innovativeness, and implications.

### E. BROADER IMPLICATIONS OF CROSS-SESSION AND CROSS-DEVICE SEARCH STUDIES

The fifth research question (*RQ5*) relates to the broader implications of the research on cross-session and cross-device search. Although some of the papers do not refer to consumers explicitly, every user and every web searcher is also a consumer, with a certain portion of the web search activity relating to the information need concerning a product/brand future purchase. Understanding search behavior, including high-level motivation, search intent, goals, and search process, is essential for consumer behavior studies. Thus, the implications of the analyzed research studies can be generalized. Deep knowledge about user (consumer) search behavior means that the results oriented at developing better search algorithms, interfaces, and creating tools supporting users by multi-session search tasks can be also utilized to engage with consumers while researching

product/brand related information. Thus, the results have direct implications, not only for online businesses, but for all business and organisations, specifically regarding their marketing strategies.

For marketers, it is essential to understand the impact of cross-session and cross-device on marketing strategies. Companies and brands have to be found when users search for keywords relevant to their business [51]. Thus, one of the marketing implications of cross-session and cross-device search is that it is not only important to be visible when people search for the information initially, but the brand/product also needs to remain visible to a broad variety of (evolving) keywords to stay considered throughout the whole information research process. Search engine marketing is already dealing with issues of achieving high search visibility for a variety of keywords, by implementing paid per click (PPC) and search engine optimization (SEO) strategies (e.g., [7], [52]–[55]). Marketing implications of cross-session and cross-device, however, go well beyond search engine marketing and relate to every business and organization, whether they consider their search engine presence or not. The major implications for marketing - extending the area of search engine marketing - include the central role of search visibility in marketing, and the specific importance of search visibility by communication campaigns that include offline media.

Understanding the user behavior and the complexity of search tasks spanning long time periods and multiple sessions is relevant for digital or online marketing, specifically search engine marketing. Regardless the focus or the marketing strategy of a business, people will be doing their research on the company and its products online. Due to the pivotal role of search visibility, search engine marketing should now be included in every marketing plan. Some published studies focus on the impacts of cross-session and cross-device search on marketing published [56], pointing academics and practitioners toward the paradigm of search-centric marketing, stressing the central role of search visibility in the modern integrated marketing and Omni channel marketing concepts [7], [57], [58].

The way users interact with media has changed from passive and unidirectional to proactive and interactive, with users commenting or rating TV shows and searching for information regarding characters, facts, multimedia content or any other related material [59]. Multi-screening is a term related to cross-device search as information search is, along with social media use and chatting, one of the typical multi-screening activities [60]. A few studies have already been published on multi-screening and its impact on marketing, for example advertising outcomes [61]. Research in the marketing field can now be directed towards the complex issues and impact of cross-device search. Search visibility has become essential for TV advertisers, as viewers are responding to TV advertisements by searching online. High search visibility integrates offline and online communication channels [62], [63]. Following the initial searches, high search visibility for general

and communication campaign-related keywords enable consumers to re-find the information they have already evaluated in a previous session or on a previous device. This gives the brand, product, and/or company the chance to remain considered during the whole information research process, leading towards the final purchasing decision. Thus, applying the results of cross-session and cross-device search on marketing communication means that any communication campaign that is not built around search visibility, will not reach its potential efficacy, extending the traditional concept of integrated marketing communication (IMC).

## F. FUTURE RESEARCH DIRECTIONS

This literature review also identifies the current research gap, i.e. the directions for future research in cross-session and cross-device search (RQ6). The future research directions can be clustered in three main focus areas:

Firstly, after investigating RQ2, we identify that technical aspects of cross-session and cross-device search represents an important focus area that should be further investigated. Such research can focus on emerging technologies that have not been available to users and researchers before, while trying to bridge the gap between the theoretically developed models, search engines, interfaces and real-world applications. Some examples of technical aspects that can be investigated include:

- How can modern browsers enable re-finding and re-accessing information on any device, due to being logged in using the same credentials?
- How can internet connected devices such as appliances, be used in terms of cross-session and cross-device search? This research may include a focus on virtual voice-based assistants (VA) and their role, functions, and positions in terms of cross-session and cross-device search. One such early study is [64], where a prototype extending VA capabilities enables it to consider inputs from devices such as smart watches, providing users with access to multiple search results and search verticals. Similarly, devices connected to the internet, fridges, cars or other IoT devices with built in microphone can serve as an input for search in the smart home. Thus, it can be expected that future research on cross-session and cross-device will investigate how the IoT concept and smart internet-connected devices affect information re-finding and the consumer purchasing decision-making process.

Secondly, stemming from investigating RQ3, opportunities exist to expand the methodological aspects of the research, such as using different methodologies than the previous studies, increasing the sample size (especially during experiments), adjust the sample characteristics to enable broader generalization of the results (e.g. by not including only university staff and students) and including participants or data from other countries in the research sample.

Thirdly, in line with the discussion about broader business and marketing implications of the research on cross-session

and cross-device search (RQ5), it is recommended that future research studies focus on interdisciplinary applications. For example, opportunities exist to improve understanding of i) the consumer information search process that includes multiple sessions and/or multiple devices, ii) implications of cross-session and cross-device search for business and marketing strategies, and iii) the possibilities of designing integrated communication campaigns containing the elements that enable users to re-find information related to the communication campaign/advertising on multiple devices. This includes investigating the relationship between search engine ranking for specific keywords and information search in context of cross-session and cross-device search.

## VI. CONTRIBUTION OF THE STUDY

In this review two decades of research on cross-session and cross-device search (2000 – 2020) was synthesized and analyzed. The paper contributes to the discipline in multiple ways:

Firstly, by identifying the terminology associated with cross-session and cross-device search, researchers now have a comprehensive overview of the area. They will also be able to identify all relevant resources for the topic they are interested in by including the terms as keywords when searching for literature. The terms that were used in more than one paper are cross-session search, multiple information seeking episodes, multi-session search, and multi-session search tasks (Table 2).

Secondly, identification of the focus areas of the research on cross-session and cross-device search enables researchers to continue the conversation by adding new insights to the already discussed topics, suggesting new solutions or investigating similar or connected issues. Some of the topics at the forefront of the research are search intent or motivation of users to search within multiple sessions, referred to as search missions or high-level search tasks, session grouping, assigning search queries to search tasks or prediction of the chance of users returning to their search mission in another session (Tables 3 and 4).

Thirdly, this paper analysis previous research in terms of the various research methods and sample details. Researchers now have a comprehensive overview of the work that was done in this area and they can use this knowledge when designing their own research. For example, the knowledge about sampling details (including sample size and country affiliations) can open avenues for future research, by increasing the sample size when using the same methodology or by focusing on regions that were not covered in previous studies. The research was conducted mostly on user samples from USA and China (Table 5). The most popular methodologies include experiment, and query log analysis (Table 7).

Fourthly, highlighting the most cited publications in this area informs researchers about the most influential authors who resonate with the academic community and the research studies they should consider including in their own studies. Three papers, namely Kotov (2011), Morris et al. (2008),

and Liu and Belkin (2010), were cited more than 100 times (Table 8). Identifying implications of the previous research that go beyond IS/IT can help create ties with other disciplines that can benefit from this research and for which the research results are relevant. Researchers from these disciplines will be informed about the importance of studying cross-session and cross-device search. Interdisciplinary conversations can be initiated and further research crossing traditional boundaries of disciplines can be initiated.

Lastly, identifying the current research gap, i.e. the directions for future research, offers inspiration and a detailed research agenda to researchers who want to conduct research in the area, thus saving time spent to identify the research gap. This shapes the future of research in this area by pointing out the important aspects that have not been investigated and avoiding the areas that already have been covered sufficiently. Amongst others, we believe that the broader community of both marketing academics and practitioners can benefit from the results by conducting further theoretical and empirical research based on these results.

## VII. LIMITATIONS

There are limitations to our study. Firstly, although an effort was made to search for relevant keywords in resources in different databases the search will never be entirely exhaustive, as some relevant studies may have been omitted due to the filtering process that was adopted. Secondly, only journal and conference papers were included in the research, while books, book chapters, monographs, dissertations, and other potentially relevant studies and reports were omitted. Thirdly, the research focus identified in this study is not definitive. Future research can also frame the results of this literature review in terms of theoretical focus across multiple disciplines.

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