Received: 11 October 2023 | Accepted: 15 October 2023

DOI: 10.1002/asi.24845

GUEST EDITORIAL

JASIST WILEY

JASIST Special Issue Editorial: Re-orienting search engine research in information science

1 | INTRODUCTION: THE GROWING IMPORTANCE OF SEARCH ENGINES

General web search engines constitute a fundamental part of today's information infrastructure. They have made it possible to find almost anything on the internet, usually by typing a few keywords into an empty search box, but increasingly also by voice recognition. In fact, search engines are now so integrated into devices and practices that they mostly go unnoticed. They have come to shape our lives as well as the society and culture we live in, and our lives and society also affect these information resources in their turn. We use them in school, for work, in planning our holidays, when searching for products and services and in politics—just to name a few important areas.

Given the centrality of general web search engines in how and what we know, and in whose products, services and messages get noticed, it is no surprise that content providers are doing everything they can, using various types of search engine optimization (SEO) and marketing (SEM), to achieve the highest possible rank and thus visibility on search engine result pages (SERP). When we talk about the *uses* of search engines, it is important to remember that there are other users than the ones we usually think of. Besides so-called end users or searchers, those who want to be found (content producers) are also users of a search engine, but also there are also those who do not want to be found.

The search engine landscape is dominated by a few corporations that have divided the global market more or less along geopolitical lines: broadly speaking, Baidu in China, Yandex in Russia and Google in much of the Western world. Microsoft's Bing is often mentioned as the most important competitor to Google, but this search engine has failed to gain significant market shares. In the United States, Bing has a market share of about 6%, and 3% in Europe (Statcounter, 2023). More competition between search engines is often called for, but this is extremely difficult to achieve within the current political and economic system.

Given how topical search engines are in our evolving information age, we, the editors, are particularly pleased to present the articles on this subject included in this special issue of JASIST. This introductory essay in the special issue consists of five sections besides this introduction. Section 2 provides an overview of search engine analyses pursued within the information sciences. Section 3 situates these previous contributions within a broader cross-disciplinary discussion, as it has evolved over the past decades. Section 4 brings the review up to date by focusing on the most recent studies which have revitalized the field of search engine studies. Section 5 presents the research questions, methods and findings of the articles in this special issue. Section 6 concludes with an overview of present-day and near-future trends of importance in search engine development and research which the studies here have also addressed.

2 | SEARCH (ENGINES) IN INFORMATION SCIENCE

While general web search engines are a cornerstone of today's information infrastructure—economically, culturally, politically, technically, etc.—and have become an integral part of everyday life on many levels, information science has rarely considered general web search engines from a perspective that takes into account their various social implications. Moreover, not only is there too little research on search engines in information science, but what little there is is fragmented into different subfields, and these fields do not always communicate well with one another.

In information science, search engines have been studied mainly in two subfields, those regarding information retrieval and information behavior.

It can be said that information retrieval systems, which include search engines, have been a central topic in information science since the discipline's inception in the 1960s (Saracevic, 2009). Fundamental concepts such as relevance or precision and recall originated in information retrieval, where the goal was often to evaluate the

effectiveness of systems in these respects and to develop appropriate methods. Most notably, relevance, one of the most central concepts also for contemporary search engines, has its origin in information science (Saracevic, 1975, 2016). Still, there are some blind spots, especially regarding what role different types of relevance play when it comes to search engines (Sundin et al., 2022). Today's search engines index a plethora of content and have a very low quality threshold when it comes to including documents in their indexes (Lewandowski, 2023, pp. 28–40). Therefore, ranking results in a way that benefits users and, at the same time, provides societal relevance is paramount, but this process is also extremely complex, consequential and contentious.

In addition, information retrieval research has contributed to the development of search engines by creating indexing methods (see, e.g., Sparck Jones, 1972) and ranking algorithms, with link-based algorithms based on central ideas from information science, namely citation analysis (Garfield, 1979). Evaluation campaigns like TREC (Harman & Voorhees, 2006) and CLEF (Ferro & Peters, 2019) have developed solid methods and procedures to thoroughly test search engines. In addition, information retrieval research has contributed to the development of search engines by developing indexing methods (see, e.g., Sparck Jones, 1972) and ranking algorithms, with link-based algorithms based on key ideas from information science, most notably citation analysis (Garfield, 1979). Nevertheless, there is little interest in web search engines in information retrieval research when it comes to commercial web search engines and the information environment they have created. The focus is still largely on incremental improvement of search systems rather than on understanding the commercial search environment as a whole. Therefore, as information retrieval systems became big business and technical development moved into the world of patents and trade secrets, academic research on information retrieval became increasingly marginalized.

On the user side, information science research has contributed to developing and understanding search engines through developing information-seeking models (see, e.g., Bates, 1989; Belkin et al., 1982; Kuhlthau, 2003) that are employed in system development (White, 2016). Information behavior research is concerned with how people deal with information in general, and the field has produced a vast body of empirical work on people's behavior when looking for and using information, as well as producing numerous (some would say far too many) models. The more recent turn to a focus on information practices has led to a focus on information in social practices as such. But this renewed and certainly much-needed interest in how people create meaning from information has often eclipsed actual information systems, including web search engines as well as their use and meaning in people's practices.

This special issue is a first step in addressing these shortcomings by drawing the attention of information science to search engines and existing research, and hopefully stimulating a renewed interest in the study of this search and search technologies. These constitute nothing less than a critical infrastructure in today's society and will continue to do so in one way or another in the future. Information science, with its rich tradition in the study of both information retrieval systems and how people search for information, provides a good starting point for researching contemporary search engines (Lewandowski, Suenkler & Schultheiss, 2020; Lewandowski et al., 2021). Its openness to other disciplines, human and social as well as technical, means that it can also serve as a hub for integrating research from other fields.

3 | SEARCH ENGINES ACROSS FIELDS AND DISCIPLINES

Search engines and their uses have been studied in different disciplines and from different theoretical perspectives, also far beyond the confines of information science. This section presents in broad strokes some main strands of this cross-disciplinary research that have emerged in recent years to provide context for the articles in this special issue of the journal.

Media-centered and device-centered research on search engines has long existed alongside people-centered studies and research that focuses on society, economics or politics. In addition to information science, library and information science (LIS), and information studies, the topic has been addressed in disciplines as diverse as science and technology studies (STS), media and communication studies, political science, organizational studies, education, psychology, human–computer interaction (HCI), and computer science, to name but a few.

While some focus on the uses of search engines in general (see, e.g., Halavais, 2018), others examine specific commercial search engines, such as Google (see, e.g., Hillis et al., 2012), but also Yandex, Baidu or various regional services (Zavadski & Toepfl, 2019). Some studies look at specific groups, such as teenagers (Andersson, 2017), older people (Sanchiz et al., 2017), or specific social settings or professions (Gudmundsdottir & Hatlevik, 2020). Others focus on the use of search engines in relation to other platforms, such as social media (see, e.g., Delmastro & Splendore, 2021).

More recently, with the emergence of critical algorithm, critical data and critical AI studies, more emphasis

has been placed on the various ways in which Google, in particular, is implicated in society's information disorders and problems with misinformation and algorithmic biases that reinforce prejudice and injustice (Graham, 2023a, 2023b; Noble, 2018; Puschmann, 2019). Important questions have been raised about the extent to which Google is contributing to reshaping the very understanding of facts and knowledge (Iliadis, 2023). Another analytical angle pertains to the central role of Google in capitalism (Bilić, 2018; Mager, 2012), while others have addressed the role of commercial search engines in reinforcing confirmation biases, partisanship or hostile media effects (Tripodi, 2022).

Despite search engines being researched from many different angles and for a relatively long time, the field is extremely scattered. Not only are researchers often unaware of each other's work across disciplines—even across subfields of the same discipline, there are few connections. Different disciplinary investigations run in parallel and rarely meet in a productive way. Furthermore, the more commercial search engines recede into the background, the more difficult it becomes to notice and study them. In addition, their functioning is largely opaque and beyond the control of society, which in many cases means that the data available for research remains as a matter of guesswork. This poses methodological challenges and might require creative approaches to data collection and novel methods, as well as research designs that are open to new influences and experimental tactics.

4 | RENEWED INTEREST IN SEARCH ENGINE RESEARCH

It is to be welcomed that there has been a resurgence of interest in search engine research in recent years, resulting in the publication of a number of books and special issues. To bring our preceding overview as up-to-date as is possible, we here look at the most representative latest studies which have revitalized the field, and whose example our special issue studies have in various ways aimed to follow.

Safya Noble's (2018) *Algorithms of oppression: How search engines re-enforce racism* succinctly demonstrated the extent to which Google is implicated in perpetuating racist structures in society. Her book has been widely discussed in the media, opening up this important discussion to the general public. In *Invisible search and online search engines: The ubiquity of search in everyday life*, Haider and Sundin (2019) focus on search and search engines as a component of social practices. They discuss what it means that search engines, as an invisible information infrastructure, are increasingly going unnoticed in society and everyday life, and address the related challenges for media and information literacy.

In *The propagandists' playbook: How conservative elites manipulate search and threaten democracy*, Francesca Tripodi (2022) investigates how conservative groups in the United States use search engines not only to understand political discourse but also to influence it. Specifically, she explores their preference for personal interpretations of texts over expert opinions. Since search queries often mirror users' political stances, interest groups can easily manipulate search results to align with their agendas. The book *Understanding search engines* by Dirk Lewandowski (2023) offers a comprehensive overview of search engines from five key angles, focused on technical issues, users, internet-based research, economic aspects, and societal aspects. The book serves as both a general introduction to web search engines and search engine studies and is a valuable reference for researchers looking to integrate their work into this broader area. Rosie Graham's (2023a) *Investigating Google's search engine: Ethics, algorithms, and the machines built to read us* highlights the persistent structural injustices in search engine bias. This book is a valuable resource for researchers interested in search engine bias, particularly in the context of automatically generated query suggestions and problematic search results and with a focus on LGBTQ+ issues.

The renewed interest in search engine studies is also shown by the publication of special issues in journals, like this one. A recently published special issue of *Big Data and Society* (Mager et al., 2023) focuses on "The State of Google Critique and Intervention." The topics covered in this special issue will sound familiar to information science researchers: Methods for investigating offensive search results (Rogers, 2023), data voids and racism (Norocel & Lewandowski, 2023), how Google creates ignorances on the climate crisis (Haider & Rödl, 2023), ethical concerns associated with Google's auto-complete function (Graham, 2023b), European alternatives to Google (Mager, 2023), as well as conceptual development to nuance the critique "big tech" (Rieder, 2022). In the same year a special issue of *Social Media and Society* (Iliadis & Ford, 2023) appeared under the title "Semantic Media." The majority of contributions in this issue concern, in one way or another, search processes, search engines and address their various implications in how meaning and knowledge emerge in society (Dobreski et al., 2023; Ford & Iliadis, 2023; Giomelakis, 2023; Jobin, 2023; Tripodi & Dave, 2023).

Apart from these books and special issues, also many new journal articles and conference papers have been published, bringing the field forward by introducing new aspects to search engine research or providing thorough

treatment of previously identified but under-researched topics. We have to leave over giving an overview of this published work to a future literature review.

In sum for now, we can say that, the flurry of recent publications and the breadth and diversity of the issues broached indicates that the interdisciplinary field of search engine research is undergoing a revived interest. Information science already contributes to this interdisciplinary conversation, with its unique perspective on information search and search engine users, bridging technical and social aspects in a unique way. However, since this is an emerging field of socially relevant research, we look forward and hope to encourage many more contributions in this area from information science.

5 | AN OVERVIEW OF CONTRIBUTIONS IN THIS ISSUE

This special issue consists of this editorial, one opinion paper and eight research articles. These are briefly summarized below, in the order in which the articles are included in our issue. For each study, we briefly present the research questions addressed, the methods used and the findings reached in the articles in this special issue.

In their opinion paper "Impact and development of an Open Web Index for open web search," Michael Granitzer and his colleagues (Granitzer et al., 2024) convincingly argue for the need to develop a more diverse and transparent search engine ecosystem. Using six principles, they lay out how this can be achieved through a collaborative Open Data approach. Building on Lewandowski's (2014, 2019) proposals, the authors have identified how the cost of a competitive index is the main obstacle to a more diverse search engine market. They suggest the creation and maintenance of an Open Web Index (OWI) that can be used by multiple search engines and which, they argue, would enable a more open, more diverse and ultimately fairer search (engine) ecosystem.

Over the years, search engine result pages have become more and more complex, including results from many different source types, including news, images, and video (Oliveira & Teixeira Lopes, 2023). Pardi et al. (2024), in their article titled "The influence of knowledge type and source reputation on preferences for website or video search results," discuss an investigation into the factors influencing the choice of online search results in hypothetical learning tasks. They designed an experiment that explores how contextual factors (knowledge type and the extent of spatiotemporal changes associated with that knowledge) and resource factors (resource type and the reputation of the source) impact the likelihood of selecting a particular search result. The study found that the type of knowledge relevant to the learning task influenced whether participants chose a video or website as their search result. This finding has significant implications for understanding online search behavior. Without considering the interaction between knowledge type and resource type, one might erroneously conclude that a general preference exists for video content in web searches. Apart from the empirical results, the article gives an example of how experimental designs can help better understand user behavior in web search.

In Tim Gorichanaz's (2024) conceptual paper entitled "Virtuous search: A framework for intellectual virtue in online search," the author intertwines information ethics and the epistemology of virtue, and applies these two perspectives to research on search and search engines. This ambitious framework, which is well anchored in information science, elucidates the intricate interplay between the searcher, the system and society at large, and emphasizes their mutual influences. The importance of linking the individual, the search engine and the society is a very welcome reminder for all researchers in the field. This paper provides a normative agenda and offers recommendations that are relevant not only to research, but also to search engine design and educational strategies in the field. The paper paves the way for new research and insights in the field of search and search engine research. In a broader sense, the paper is also a reminder that we need not only to do empirical research, but also to develop a broader framework that gives meaning to all empirical work.

In "Dark sides of artificial intelligence: The dangers of automated decision-making in search engine advertising," by Carsten D. Schultz et al. (2024), the authors explore the pressing question of what the potential dangers of automated bidding by search engines are, and how they can effectively be countered? Using empirical data from a real case, the authors show that the integration of artificial intelligence can indeed lead to reduced advertisement performance. They point out the challenges associated with the lack of transparency in AI-driven decision-making. Furthermore, they emphasize the importance of better understanding the technical workings of search engines, and of introducing control mechanisms. These concerns go beyond just those relevant to online marketing, and lead to broader questions about how we understand the influence of search engines on our society.

In their contribution, Helena Häußler et al. (2024) explore the question of how people perceive and experience risks and potential negative outcomes of web search. The question they ask is also the article's title: "Is ggoling risky?" Although this sounds like a straightforward

question that can be responded to with a simple yes or no, the authors' analysis and resulting answer is anything but simple. They provide an overview of different understandings of risk in social theory and use these as a background for examining what risks people associate with the use of web search engines. Based on a large data set collected with a questionnaire, interesting differences between people's experiences and perceptions emerge in this article. Most people limit the understanding of risks associated with web search to the fact that the results delivered are inaccurate, while delayed negative effects or privacy concerns are rarely perceived as risks. A clear difference can be seen in how women and men associate risks with web search and what is seen as risk, suggesting that different expectations are placed on technology. The findings presented in this article clearly show that people's understanding of web search engines and the risks and benefits associated with them varies widely and, importantly, that this is an area that is still very under-researched.

Search engine bias has been a topic of continuous interest to researchers, within the information sciences and beyond. While there has been considerable work on how to mitigate bias through algorithms, little work has considered the user interface. Paramita et al. (2024) design and evaluate eight different interface designs that raise the awareness for potential biases in news search engines. They follow two approaches: firstly, a system can be used to inform users of potential biases in the results, and secondly, users can be allowed to change the ranking of the results. The user study found that a combination of the two approaches is the best way to help users become aware of potential biases, as well as to give them a tool to re-rank search results.

The article by Renee Morrison (2024) proposes Critical Discourse Analysis (CDA) as a theory and method for search engine research. The paper, entitled "Making the invisible visible: Critical Discourse Analysis as a tool for search engine research" is thus primarily a conceptual contribution, but the paper also provides examples of what CDA can contribute in terms of new research questions and new methodological approaches. Morrison guides the reader through Fairclough's (1993) model and illustrates what the three levels of enquiry (micro, meso, and macro) might mean for search engine research. In particular, the paper illustrates how CDA can be used to critically understand search engines by looking in more detail at two previous studies (Morrison, 2020; Noble, 2012) in which CDA was used to investigate them. In relation to previous information science research, the paper provides a strong argument for the need to combine systems-oriented and user-oriented studies on search engines.

There has been a long and ongoing debate on how search engines should be regulated and how search and searching skills should be taught in schools. One of the primary sources for policymakers in the relevant areas is national surveys of internet and search engine uses. But what questions are addressed in these surveys? In their contribution, Andersson and Sundin (2024) investigate reports on this subject from Sweden, the UK, and the United States, covering the years from 2015 to 2021. Analyzing the questions from a theoretical perspective from infrastructure theory, they find that these surveys further contribute to the invisibility of search engines, as described in earlier research (Andersen, 2018; Andersson, 2017; Haider & Sundin, 2019). This becomes problematic when policymakers base their discussions and decisions on what has been asked in surveys, not considering anything that has not been asked—or even could not be asked. This can lead to insufficient attention being paid to search engines in multiple areas, including the general formation of public knowledge of search engines in society and their use and effects in school education.

The contribution by Rowland et al. (2024) explores how Google Search presents and shapes information on a particular issue where public perception is largely negative: carbon capture and storage (CCS). This is a controversial technology that is promoted, for example, by the EU, as part of the arsenal of technical solutions to mitigate further climate change. Through a qualitative analysis comparing search results in three different countries (France, Spain, and Portugal), the study examines how Google's ranking parameters and user interfaces affect the information which users encounter when searching for CCS-related content. The main focus is on the content found on the first pages of search engine results (SERP). In addition, attention is paid to the criteria which Google uses to rank websites, and the content and format of the sources suggested and promoted. The study confirms that Google Search tends to prioritize Wikipedia pages and sources presented in a Q&A format. The most interesting outcome of the study is that it reveals country-specific differences that reflect different levels of interest and investment in CCS at the national level. Overarching and uniform infrastructural aspects such as ranking factors or relevance signals, which are largely informed by Google's corporate and technical logic, intermingle with national discussions and the different local conditions, actors, and interests. In this way, the study shows the importance of search engine algorithms and interfaces for shaping public perception and knowledge, but also how local conditions contribute to issues being shaped by search engine technology.

6 | THE FUTURE OF INFORMATION SEARCH: REVOLUTION, EVOLUTION OR BOTH AT ONCE?

Before giving the floor to our article authors, we wish to conclude this introductory editorial by identifying future trends and research topics of particular interest within the rapidly evolving field of search engine development and search engine studies. We believe that these present-day and near-future trends and topics should be kept in mind in seeing how the studies included here address them.

In the media, it seems that search engines and search are at a crossroads. Since ChatGPT 3.5 became publicly available in November 2022, thousands upon thousands of articles have been written about how Large Language Models (LLM) and related developments in machine learning will affect almost all parts of society—and not necessarily always for the better. Of course, the practice of finding information has also been in the spotlight. Some voices have spoken about a revolution in the search for information, while others see more of a continuation.

So is generative AI a Google killer or not? It is difficult to predict the future, especially when you are in the midst of a technological shift. On the one hand, Bing, which has partnered with OpenAI and ChatGPT, wanted it to sound like generative AI was a game changer. Bing's CEO stated in an interview in early 2023: "it's not just a search engine; it's an answer engine—because we have always had answers, but with these large models, the fidelity of the answers just gets so much better" (Nilay Patel, 2023). In some ways, ChatGPT, Google's Bard and other LLM products have the potential to fundamentally change our understanding of finding out about a topic. Instead of using a search engine that gives you a large number of links ordered by relevance, generative AI products create an "answer" written in natural language without a link to a source. You get one version of an answer instead of references to different sources with potentially many different answers. Furthermore, generative AI products work in a fundamentally different way compared to web search engines. Their "answers" are based on an enormous dataset that is trained to produce human-like texts after input from a user (or a bot).

On the other hand, the information sciences have long distinguished between searching for a document and searching for an answer to a question. Already in the early 1960s, the late well-known information scientist Brian Vickery (1918–2009) illustrated this difference by exemplifying how the answer to a question about the height of Mount Everest can be given in two different ways: "'The height of Mt. Everest is given on page 900, volume 8, of Encyclopaedia Britannica'; in the other case, it would be 'The height of Mt. Everest is 29,002ft'" (Vickery, 1961, pp. 2–3). For a long time, search engines only referred the user to documents (webpages), just as the old library catalogue did, but for some years now the trend has been increasingly to provide the user with an answer. Google introduced its Knowledge Graph feature back in 2012 to give users direct answers to their questions in the form of snippets or structured facts, often taken from Wikipedia, without having to follow a link.

Some search engines have incorporated elements of generative AI, but search engines still rely on an index. In Bing, You.com, and Perplexity, for example, you get the result of a search as natural language text with links to websites. However, it is important to understand that in these three examples, the search engines primarily rely on generative AI to distill natural language text from the websites to which the first links lead. In some ways, the examples seem to be an attempt to look like a purely generative AI product, but the technology is primarily traditional search engine technology, including information extraction. Since the results are displayed in natural language and not just as links to websites, the traditional functioning of a search engine runs the risk of becoming more hidden to the user.

Whether we see the introduction of generative AI products in search and search engines as a radical change or rather a continuation of a long tradition towards more answers instead of documents, it is obvious that new research is needed. In a recent workshop (September 7, 2023) at the University of Applied Sciences in Hamburg, Germany, on the impact of generative AI on search and search engine research, organized by Dirk Lewandowski and Olof Sundin, a number of fascinating topics and suggestions for future research were discussed, including:

- What does the ongoing development of generative AI mean for search engines and research in the area?
- How will a transition from querying to prompting impact user behavior and expectations of users who have become accustomed to chat dialogues for information search?
- What are the potential risks associated with the spread of misinformation as generative AI gains traction?
- What methodological considerations do researchers need to address to effectively study the impact of generative AI on information seeking?

These and other questions will most likely be topics for many upcoming research papers, articles, books, and journal special issues. As the Editors of this special issue, we would like to emphasize the need to anchor this new

research in the long tradition of search engine research in the information sciences. The wheel does not need to be re-invented, but it needs to be adapted to new and emerging challenges.

ACKNOWLEDGMENTS

As Editors of this special issue we would like to thank the reviewers for their efforts and many insightful comments. The idea for this special issue grew out of conversations held as part of the interdisciplinary research theme "In Search of Search and its Engines" led by Olof Sundin and Alison Gerber at the Pufendorf Institute for Advanced Studies, Lund University, Sweden. We thank all the participating researchers who shared their insights and expertise on search and search engines.

Dirk Lewandowski[1,2]
Jutta Haider[3]
Olof Sundin[4]

[1]*University of Duisburg-Essen, Duisburg, Germany*
[2]*Hamburg University of Applied Sciences, Hamburg, Germany*
[3]*Swedish School of Library and Information Science, University of Borås, Borås, Sweden*
[4]*Department of Arts and Cultural Sciences, Lund University, Lund, Sweden*

Correspondence
Dirk Lewandowski, University of Duisburg-Essen, Duisburg, Germany.
Email: dirk.lewandowski@haw-hamburg.de

ORCID

Dirk Lewandowski https://orcid.org/0000-0002-2674-9509
Jutta Haider https://orcid.org/0000-0002-8293-8208

REFERENCES

Andersen, J. (2018). Archiving, ordering, and searching: Search engines, algorithms, databases, and deep mediatization. *Media, Culture and Society*, *40*(8), 1135–1150. https://doi.org/10.1177/0163443718754652

Andersson, C. (2017). "Google is not fun": An investigation of how Swedish teenagers frame online searching. *Journal of Documentation*, *73*(6), 1244–1260. https://doi.org/10.1108/JD-03-2017-0048

Andersson, C., & Sundin, O. (2024). The elusive search engine: How search engine use is reflected in survey reports. *Journal of the Association for Information Science and Technology*, *75*(5), 613–624. https://doi.org/10.1002/asi.24819

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

Belkin, N. J., Oddy, R. N., & Brooks, H. M. (1982). ASK for information retrieval: Part I. Background and theory. *Journal of Documentation*, *38*(2), 61–71.

Bilić, P. (2018). The production of algorithms and the cultural politics of web search. In P. Bilić, J. Primorac, & B. Valtýsson (Eds.), *Technologies of labour and the politics of contradiction* (pp. 57–76). Springer. https://doi.org/10.1007/978-3-319-76279-1_4

Delmastro, M., & Splendore, S. (2021). Google, Facebook and what else? Measuring the hybridity of Italian journalists by their use of sources. *European Journal of Communication*, *36*(1), 4–20. https://doi.org/10.1177/0267323120940912

Dobreski, B., Ridenour, L., & Resnick, M. (2023). Reproductive health and semantics: Representations of abortion in semantic models and search applications. *Social Media + Society*, *9*, 3. https://doi.org/10.1177/20563051231195553

Fairclough, N. (1993). *Discourse and social change*. Policy Press.

Ferro, N., & Peters, C. (2019). From multilingual to multimodal: The evolution of CLEF over two decades. In *Information retrieval evaluation in a changing world: Lessons learned from 20 years of CLEF* (pp. 3–44). Springer.

Ford, H., & Iliadis, A. (2023). Wikidata as semantic infrastructure: Knowledge representation, data labor, and truth in a more-than-technical project. *Social Media + Society*, *9*, 3. https://doi.org/10.1177/20563051231195552

Garfield, E. (1979). *Citation indexing—Its theory and application in science, technology, and humanities*. Wiley.

Giomelakis, D. (2023). Semantic search engine optimization in the news media industry: Challenges and impact on media outlets and journalism practice in Greece. *Social Media + Society*, *9*, 3. https://doi.org/10.1177/20563051231195545

Gorichanaz, T. (2024). Virtuous search: A framework for intellectual virtue in online search. *Journal of the Association for Information Science and Technology*, *75*(5), 538–549. https://doi.org/10.1002/asi.24832

Graham, R. (2023a). *Investigating Google's search engine: Ethics, algorithms, and the machines built to read us*. Bloomsbury Academic.

Graham, R. (2023b). The ethical dimensions of Google autocomplete. *Big Data & Society*, *10*(1), 205395172311565. https://doi.org/10.1177/2053951723115651

Granitzer, M., Voigt, S., Fathima, N. A., Golasowski, M., Guetl, C., Hecking, T., Hendriksen, G., Hiemstra, D., Martinovič, J., Mitrović, J., Mlakar, I., Moiras, S., Nussbaumer, A., Öster, P., Potthast, M., Srdič, M. S., Megi, S., Slaninová, K., Stein, B., ... Zerhoudi, S. (2024). Impact and development of an Open Web Index for open web search. *Journal of the Association for Information Science and Technology*, *75*(5), 512–520. https://doi.org/10.1002/asi.24818

Gudmundsdottir, G. B., & Hatlevik, O. E. (2020). "I just Google it"—Developing professional digital competence and preparing student teachers to exercise responsible ICT use. *Nordic Journal of Comparative and International Education (NJCIE)*, *4*(3–4), 39–55. https://doi.org/10.7577/njcie.3752

Kuhlthau, C. C. (2003). *Seeking meaning: A process approach to library and information services*. ABC-CLIO.

Haider, J., & Rödl, M. (2023). Google Search and the creation of ignorance: The case of the climate crisis. *Big Data and Society*, *10*, 1–12. https://doi.org/10.1177/20539517231158997

Haider, J., & Sundin, O. (2019). *Invisible search and online search engines: The ubiquity of search in everyday life*. Routledge.

Halavais, A. (2018). *Search engine society* (2nd ed.). Polity Press.

Harman, D. K., & Voorhees, E. M. (2006). TREC: An overview. In B. Cronin (Ed.), *Annual review of information science and technology* (Vol. 40, pp. 113–155). Information Today.

Häußler, H., Schultheiß, S., & Lewandowski, D. (2024). Is googling risky? A study on risk perception and experiences of adverse consequences in web search. *Journal of the Association for Information Science and Technology*, *75*(5), 567–580. https://doi.org/10.1002/asi.24802

Hillis, K., Petit, M., & Jarrett, K. (2012). *Google and the culture of search*. Routledge.

Iliadis, A. (2023). *Semantic media: Mapping meaning on the internet*. Polity Press.

Iliadis, A., & Ford, H. (2023). Fast facts: Platforms from personalization to centralization. *Social Media + Society*, *9*, 3. https://doi.org/10.1177/20563051231195546

Jobin, A. (2023). Valuating words: Semantic practices in web search advertising. *Social Media + Society*, *9*, 3. https://doi.org/10.1177/20563051231195549

Lewandowski, D. (2014). Why we need an independent index of the Web. In R. König & M. Rasch (Eds.), *Society of the query reader: Reflections on web search* (pp. 49–58). Institute of Network Cultures.

Lewandowski, D. (2019). The web is missing an essential part of infrastructure: An Open Web Index. *Communications of the ACM*, *62*(4), 24–27. https://doi.org/10.1145/3312479

Lewandowski, D. (2023). *Understanding search engines*. Springer. https://doi.org/10.1007/978-3-031-22789-9

Lewandowski, D., Sünkler, S., & Yagci, N. (2021). The influence of search engine optimization on Google's results. In *13th ACM web science conference 2021* (pp. 12–20). ACM. https://doi.org/10.1145/3447535.3462479

Lewandowski, D., Sünkler, S., & Schultheiß, S. (2020). Studies on search: Designing meaningful IIR studies on commercial search engines. *Datenbank-Spektrum*, *20*(1), 5–15. https://doi.org/10.1007/s13222-020-00331-1

Mager, A. (2012). Algorithmic ideology: How capitalist society shapes search engines. *Information, Communication & Society*, *15*(5), 769–787. https://doi.org/10.1080/1369118X.2012.676056

Mager, A. (2023). European search? How to counter-imagine and counteract hegemonic search with European search engine projects. *Big Data & Society*, *10*(1), 205395172311631. https://doi.org/10.1177/20539517231163173

Mager, A., Norocel, O. C., & Rogers, R. (2023). Advancing search engine studies: The evolution of Google critique and intervention. *Big Data and Society*, *10*(2), 20539517231191528. https://doi.org/10.1177/20539517231191528

Morrison, R. (2020). *Search engine use in Australian home-schools: An exploration framed by the generational digital divide* (Doctoral dissertation). Griffith University.

Morrison, R. (2024). Making the invisible visible: Critical discourse analysis as a tool for search engine research. *Journal of the Association for Information Science and Technology*, *75*(5), 600–612.

Noble, S. (2012). *Searching for black girls: Old traditions in new media* (Doctoral dissertation). University of Illinois.

Noble, S. U. (2018). *Algorithms of oppression: How search engines reinforce racism*. New York University Press.

Norocel, O. C., & Lewandowski, D. (2023). Google, data voids, and the dynamics of the politics of exclusion. *Big Data & Society*, *10*(1), 205395172211490. https://doi.org/10.1177/20539517221149099

Oliveira, B., & Teixeira Lopes, C. (2023). The evolution of web search user interfaces—An archaeological analysis of Google search engine result pages. In *Proceedings of the 2023 conference on human information interaction and retrieval* (pp. 55–68). ACM. https://doi.org/10.1145/3576840.3578320

Paramita, M. L., Kasinidou, M., Kleanthous, S., Rosso, P., Kuflik, T., & Hopfgartner, F. (2024). Towards improving user awareness of search engine biases: A participatory design approach. *Journal of the Association for Information Science and Technology*, *75*(5), 581–599. https://doi.org/10.1002/asi.24826

Pardi, G., Gottschling, S., & Kammerer, Y. (2024). The influence of knowledge type and source reputation on preferences for website or video search results. *Journal of the Association for Information Science and Technology*, *75*(5), 521–537. https://doi.org/10.1002/asi.24771

Patel, N. (2023, February 18). It's not just a search engine; it's an answer engine—Because we've always had answers, but with these large models, the fidelity of the answers just gets so much better. *The Verge*. Retrieved from https://www.theverge.com/23589994/microsoft-ceo-satya-nadella-bing-chatgpt-google-search-ai

Puschmann, C. (2019). Beyond the bubble: Assessing the diversity of political search results. *Digital Journalism*, *7*(6), 824–843. https://doi.org/10.1080/21670811.2018.1539626

Rieder, B. (2022). Towards a political economy of technical systems: The case of Google. *Big Data & Society*, *9*(2), 205395172211351. https://doi.org/10.1177/20539517221135162

Rogers, R. (2023). Algorithmic probing: Prompting offensive Google results and their moderation. *Big Data & Society*, *10*(1), 20539517231176228. https://doi.org/10.1177/20539517231176228

Rowland, J., López-Asensio, S., Bagci, A., Delicado, A., & Prades, A. (2024). Shaping information and knowledge on climate change technologies: A cross-country qualitative analysis of carbon capture and storage results on Google search. *Journal of the Association for Information Science and Technology*, *75*(5), 625–639. https://doi.org/10.1002/asi.24828

Sanchiz, M., Chevalier, A., & Amadieu, F. (2017). How do older and young adults start searching for information? Impact of age, domain knowledge and problem complexity on the different steps of information searching. *Computers in Human Behavior*, *72*, 67–78. https://doi.org/10.1016/j.chb.2017.02.038

Saracevic, T. (1975). Relevance: A review of and a framework for the thinking on the notion in information science. *Journal of the American Society for Information Science*, *26*(6), 321–343. https://doi.org/10.1002/asi.4630260604

Saracevic, T. (2009). Information science. In M. J. Bates & M. N. Maack (Eds.), *Encyclopedia of library and information sciences* (3rd ed., pp. 2570–2585). Taylor & Francis.

Saracevic, T. (2016). The notion of relevance in information science: Everybody knows what relevance is. But, what is it really? *Synthesis Lectures on Information Concepts, Retrieval, and Services*, *8*(3), 1–109. https://doi.org/10.2200/S00723ED1V01Y201607ICR050

Schultz, C. D., Koch, C., & Olbrich, R. (2024). Dark sides of artificial intelligence: The dangers of automated decision-making in search engine advertising. *Journal of the Association for Information Science and Technology*, *75*(5), 550–566. https://doi.org/10.1002/asi.24798

Sparck Jones, K. (1972). A statistical interpretation of term specificity and its application in retrieval. *Journal of Documentation*, *28*(1), 11–21.

Statcounter. (2023). *Search engine market share*. Retrieved from https://gs.statcounter.com/search-engine-market-share/

Sundin, O., Lewandowski, D., & Haider, J. (2022). Whose relevance? Web search engines as multisided relevance machines. *Journal of the Association for Information Science and Technology*, *73*(5), 637–642. https://doi.org/10.1002/asi.24570

Tripodi, F. B. (2022). *The propagandists' playbook: How conservative elites manipulate search and threaten democracy*. Yale University Press.

Tripodi, F. B., & Dave, A. (2023). Abortion near me? The implications of semantic media on accessing health information. *Social Media + Society*, *9*, 3. https://doi.org/10.1177/20563051231195548

Vickery, B. C. (1961). *On retrieval system theory*. Butterworths.

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

Zavadski, A., & Toepfl, F. (2019). Querying the internet as a mnemonic practice: How search engines mediate four types of past events in Russia. *Media, Culture & Society*, *41*(1), 21–37. https://doi.org/10.1177/0163443718764565